Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Connect America Fund	)	WC Docket No. 10-90
	)	
A National Broadband Plan for Our Future	)	GN Docket No. 09-51
	)	
High cost Universal Service Support	)	WC Docket No. 05-337

COMMENTS OF THE NEBRASKA RURAL INDEPENDENT COMPANIES

Dated: July 12, 2010

The Nebraska Rural Independent Companies

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SUMMARY OF COMMENTS

The Nebraska Rural Independent Telephone Companies (the "Nebraska Companies") appreciate the opportunity to submit these comments in response to the *NOI/NPRM*.[1] The Nebraska Companies recognize the significance of a strategic plan for deploying broadband service to all Americans and the monumental effort untaken by the Commission to develop the National Broadband Plan despite inadequacies in data availability. In these comments, the Nebraska Companies principally address the following subjects: (a) shortcomings of the National Broadband Plan Model and the resulting flawed conclusions that primarily result from inadequate or incorrect data; (b) Universal Service Fund distribution issues affecting the Connect America Fund ("CAF"); and (c) a number of broad policy concerns that the Commission should consider as it proceeds with implementation of the National Broadband Plan.

The *NOI* seeks comment on a variety of questions regarding models generally and the National Broadband Plan Model (sometimes referred to herein as the "Model") in particular, including a request for comment "on any aspect of the National Broadband Plan model that may be relevant to our consideration of how to reform the existing universal service support mechanisms."[2] In response to this invitation for comments, the Nebraska Companies commissioned a study by Vantage Point Solutions of Mitchell, South Dakota ("Vantage Point") to examine certain aspects of the Model (the "*Vantage Point Study*"). A copy of the *Vantage Point Study* is annexed to these Comments as Attachment A.

In summary, the *Vantage Point Study* concludes:

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[1] Notice of Inquiry ("*NOI*") and Notice of Proposed Rulemaking ("*NPRM*") released by the Federal Communications Commission, FCC 10-58 (April 21, 2010).

[2] *Id.*, para. 16.

- The following errors in the Model cause wireless network costs to provide broadband at the proposed national standard of 4.0 Mbps downstream and 1.0 Mbps upstream (the "4/1 Mbps standard") to be understated:

  - The number of new towers required to be constructed is too low;
  - The Busy Hour Offered Load ("BHOL") design parameter does not appear to change based on the number of customers served using shared plant;
  - A network designed for a BHOL of 160 kbps (25:1 oversubscription) will not reliably provide broadband service to meet the 4/1 Mbps standard;
  - Customer traffic pattern changes moving toward streaming content require a wireless network design with a higher BHOL and a lower oversubscription ratio;
  - Microwave backhaul is unlikely to be used as prevalently as assumed;
  - The amount of spectrum assumed to be held by wireless service providers biases the Model results toward the large wireless providers, since such providers are likely to be the only carriers holding this quantity of spectrum; and
  - The derived spectral efficiency assumption appears to be too high;

- The following errors in the Model cause wireline network costs to provide broadband service at the 4/1Mbps standard to be overstated:[3]

  - The Model does not adequately reflect the capabilities of existing network infrastructure to support the 4/1 Mbps standard, in part because the Model does not give adequate consideration to the middle mile costs; and
  - The geographic areas that the Model establishes as served and unserved at the 4/1 Mbps standard are inaccurate.

Additional analysis of the Model has led the Nebraska Companies to conclude that errors in outputs from the Baseline, Cost-To-Serve and Demand and Revenue Modules of the Model cause the Assessment Module outputs to be unreliable. The Commission should not assume that errors in the Model will cancel each other out. Further, the Nebraska Companies believe that the Assessment Model contains two additional methodological errors, namely, the broadband gap estimate is based on the second-lowest gap between wireline DSL and wireless LTE technologies, and estimated broadband gaps at the census block level are aggregated to the county level to arrive at the National Broadband Gap of $23.5 billion. The use of the second

[3] Following is a partial list of the errors. A complete discussion of this subject is contained in the following comments.

lowest gap needlessly increases the gap while including the step of aggregation at the county level produce an unrealistically low estimate of the broadband gap.

The Nebraska Companies believe that CAF support should be calculated based upon consideration of a carrier's revenue and costs, but that not all unregulated services revenues should be considered. The Nebraska Companies recommend that the revenues calculation include actual revenues derived from the provision of broadband Internet service. Further, broadband Internet service revenues should be equal to the rate actually charged by the broadband provider for access to the Internet, multiplied by the number of actual subscribers.

The following comments also discuss other distribution issues affecting the CAF. The Nebraska Companies present an analysis to support the conclusion that wireline technology is preferable to wireless technology for the provision of broadband over the long term. Specifically, wireless costs increase more rapidly than wireline costs as broadband speed requirements increase and wireline technology is less costly than wireless technology in a number of circumstances.

In response to the Commission's request for comment on the geographic area that should be used in calculating the cost of deploying a network and providing services,[4] the Nebraska Companies recommend that support continues to be calculated at a study area level, but further recommend that the Commission consider that future broadband support be targeted to smaller areas. Such smaller areas may be census blocks or a "non-competitive area" that would be defined by the Commission. The purpose of these more granular areas would be to allow the Commission to provide support to targeted areas for which no business case exists for a

[4] *NOI*, paras. 41-42.

broadband provider-of-last-resort ("POLR") to invest in sufficient facilities to otherwise meet the 4/1 Mbps standard.

The Nebraska Companies also recommend that recipients of CAF support should be required to target and use such support in those identified high cost areas. Further, the Commission should allow carriers to vary capital expenditures for broadband from year to year, and in certain circumstances should allow fiber to the home installations to provide broadband in those circumstances in which this choice is a reasonable economic choice.

In addition to the foregoing positions that are responsive to the Commission's requests for comments in the *NOI*, the Nebraska Companies' comments present discussion of several broad policy concerns that should be considered by the Commission.

Based upon current broadband speed demands and projected growth rates for broadband speeds, the Nebraska Companies conclude that the 4/1 Mbps standard proposed in the National Broadband Plan is likely to be obsolete before the Commission implements even the first phase of the Broadband Plan. The Comments present data to support this conclusion. The inadequacy of the 4/1 Mbps standard is further complicated by the likelihood that wireless technology will be unable to keep pace with future bandwidth demand. Again, rationale supporting these conclusions is presented in the following Comments.

The Nebraska Companies endorse the Commission's desire to support broadband networks; however, any plan should continue to provide the important public benefits that Federal USF programs have already produced in deploying broadband and in providing high quality voice service to all Americans. Under current policy, the existing national telecommunications network has been evolving to a broadband-capable network that provides quality broadband services in many "served" areas. The Commission should make a public commitment to preserve and advance those benefits, including provision of a national network engineered to provide quality end-to-end service as well as service availability. The Nebraska Companies recommend that upcoming NOIs and NPRMs should inquire specifically concerning the technical standards needed to implement and enforce the foregoing commitment.

Of special importance is the commitment by the Commission to design and implement a POLR mechanism before it proceeds to make funding decisions to implement the National Broadband Plan. In this regard, the Commission should take into account state carrier-of-last-resort ("COLR") policies, should create a new broadband POLR policy in partnership with state commissions, and should carefully manage COLR/POLR issues in the transition to support for broadband through the CAF.

Finally, the Nebraska Companies recommend that the Commission establish collaborative relationships with state commissions to fully utilize existing and potential state USF programs. Before the Commission makes policy changes to Federal USF programs, the Commission should gather information regarding state USF programs and the likely impacts of federal USF changes on those state programs so as to "do no harm" to such state programs. A sound partnership with the states can extend the reach of limited federal financial resources. The Commission has announced that the Broadband Gap is $23.5 billion. State USF support can help to fill this gap.

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COMMENTS OF THE NEBRASKA RURAL INDEPENDENT COMPANIES

I. INTRODUCTION

The Nebraska Rural Independent Companies (the "Nebraska Companies")[5] hereby submit comments in the above-captioned proceedings. The Nebraska Companies appreciate the opportunity to file comments in response to the Notice of Inquiry ("*NOI*") and Notice of Proposed Rulemaking ("*NPRM*") released by the Federal Communications Commission (herein the "Commission") on April 21, 2010 (FCC 10-58).

The Nebraska Companies commend the Commission for taking many significant steps forward. The National Broadband Plan, the *Broadband Gap Paper*,[6] the Model Documentation

[5] The Nebraska Companies are: Arlington Telephone Company, Blair Telephone Company, Cambridge Telephone Co., Clarks Telecommunications Co., Consolidated Telephone Company, Consolidated Telco, Inc., Consolidated Telecom, Inc., The Curtis Telephone Company, Eastern Nebraska Telephone Company, Great Plains Communications, Inc., Hamilton Telephone Company, Hartington Telecommunications Co., Inc., Hershey Cooperative Telephone Company, Inc., K & M Telephone Company, Inc., The Nebraska Central Telephone Company, Northeast Nebraska Telephone Company, Rock County Telephone Company, Stanton Telephone Co., Inc., and Three River Telco.

[6] Omnibus Broadband Initiative, *The Broadband Availability Gap (OBI Technical Paper No. 1)*, April 2010 (the "*Broadband Gap Paper*").

Paper,[7] and the *NOI/NPRM* present a considerable body of research and analysis regarding the deployment and funding of universally available broadband service in the United States. The Commission's task was made even more complex by the lack of detailed data regarding broadband deployment.

The Nebraska Companies appreciate that the Commission recognizes the importance of universally available broadband to America's future. Broadband will be increasingly critical to rural areas seeking to maintain educational opportunities, quality of life and economic opportunities. The Nebraska Companies also support the Commission's broad goal of reforming Federal universal service funding and modifying existing support mechanisms that may no longer be appropriate in the modern network where switched services play an ever-declining role.

In Section II of these comments, the Nebraska Companies provide comments with regard to the National Broadband Plan's Broadband Assessment Model, including flaws in the Broadband Assessment Model that have been analyzed in the attachment to these comments that is identified as Attachment A. In Section III, the Nebraska Companies address other distribution issues affecting the Connect America Fund ("CAF"). Section IV below describes several broad policy areas that, while of fundamental importance, were not directly raised by the *NOI/NPRM.*

[7] *National Broadband Plan Model, Model Documentation*, April, 2010 ("*Model Documentation Paper*").

II. THE NATIONAL BROADBAND PLAN MODEL ISSUES AND ANALYSIS

A. Introduction

The Commission has expressed a desire to create an economic model that will assist "federal agency and congressional policy considerations relevant to the deployment and adoption of broadband."[8] To that end, the Commission designed the National Broadband Plan Model (sometimes referred to herein as the "Model") to estimate current broadband availability and to determine the economics of supplying broadband to unserved areas.[9] The *NOI* seeks comment on a variety of questions regarding models generally and the Model in particular.[10] Most broadly, the *NOI* solicits comment "on any aspect of the National Broadband Plan Model that may be relevant to our consideration of how to reform the existing universal service support mechanisms."[11]

To assist the Commission in evaluating the Model, the Nebraska Companies commissioned Vantage Point Solutions ("Vantage Point") to examine several aspects of the Model. Vantage Point is a telecommunications engineering and consulting company with broad experience with wireline and wireless networks. Vantage Point has designed and engineered hundreds of broadband access networks across the United States. Vantage Point's final report ("*Vantage Point Study*") is attached to these Comments as Attachment A, and is referred to in the following comments.[12]

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[8] *Id.*, p. 7.

[9] *Id*.

[10] *NOI,* para. 13.

[11] *Id.*, para. 16.

[12] Vantage Point Solutions, *Nebraska Rural Independent Companies: An Engineering Analysis of the Broadband Assessment Model Using Actual Network Data,* July 2010.

In this Section II, the Nebraska Companies provide comments with regard to: (a) Use of a model as a competitively neutral and efficient tool to quantify the amount of universal service fund support necessary to support networks that provide broadband and voice service; (b) the use of the National Broadband Plan Model in particular; and (c) flaws in the Model that have been analyzed in the attachment to these Comments that is identified as Attachment A. The Model itself contains four major modules, and the Nebraska Companies have organized the following portions of Section II of the comments based on that structure.

B. The Baseline Module's Broadband Availability Predictions Are Not Sufficiently Reliable to Distribute Support

The chief task of the Baseline Module was to estimate the extent of existing broadband deployments. Yet the Commission's input data for this Module were disappointingly sparse. The Commission found that national data do not exist to precisely determine the location of business and residential customers, nor do accurate data exist as to the current type and volume of broadband services demanded or available by individual customers at the census block level.[13] To meet the Congressional mandate the Commission needed to circumvent this problem so the Model relied on secondary data sources, statistical methods and proxy data.[14]

1. Input Data Were Effectively Derived From Only One State

The National Broadband Plan Model inputs for DSL availability were derived solely from Alabama, Pennsylvania and Minnesota.[15] The Alabama data covered all DSL speeds, including the Commission's proposed national standard of 4.0 Mbps downstream and 1.0 Mbps

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[13] *Model Documentation Paper*, p. 18.

[14] *Id.*

[15] *Id.*, p. 9.

upstream (the "4/1 Mbps standard"). Data from Pennsylvania and Minnesota covered a single speed that in each case was below the 4/1 Mbps standard. From a random sample of cases from this database, the Baseline Module extrapolated DSL availability for every census block in the country at six speed thresholds. One of those data runs estimated availability at the 4/1 Mbps standard.[16] The National Broadband Plan Model developers then tested their own availability estimates against the remaining cases in the database.[17] The Model was found to be 80 to 90% accurate in predicting availability of DSL within a test set of census blocks drawn from the same three states.

A basic question is whether the reliability result of 80% to 90% applies globally to all predictions or particularly to the 4/1 Mbps speed standard. There is no reason to assume that the Baseline Module is equally reliable at all six speeds at which it made predictions. Even if the Baseline Module predictions are highly reliable at an offered download speed of 768 Kbps, for example, such predictions might not be reliable for the 4/1 Mbps standard.

Limited input data appears to be a key weakness in the reliability of the outputs at the 4/1 Mbps standard. The input data at 4.0 Mbps came only from Alabama, and not from Pennsylvania or Minnesota. The Nebraska Companies therefore reasonably assume that for the 4.0 Mbps predictions, the Alabama input data had either a leading or possibly exclusive influence on the output predictions.

The fact that national broadband availability estimates were based solely or mostly on Alabama data does not provide any assurance that the predictions apply elsewhere. Moreover, by testing the Baseline Module outputs solely against that same Alabama data, the Commission

[16] *Id.*, Attachment 4, p. 2.

[17] *Id.*

has not shown that the predictions are reliable nationwide. Any systematic bias in the first half of the Alabama data that was used to make the prediction would likely be ignored when the predictions are measured against the second half of the same data set.

Based on the 2000 Census results, household location patterns in Alabama are not representative of many other states, particularly Plains States such as Nebraska. Notably, in comparison to Nebraska:

- Housing unit density, one of the major drivers of the Model, is significantly lower in Nebraska than in Alabama. Alabama has an average of 38.7 housing units per square mile, while Nebraska has only 9.4.[18]
- Housing distribution has much different ranges in the two states. The least dense county in Alabama has 7.0 housing units per square mile (hu/sq.mi), while 70% of Nebraska counties have a density of less than 7.0 hu/sq.mi. Moreover, 15% of Nebraska counties have a density that was below 1.0 hu/sq.mi. The lowest density county in Nebraska has only 0.3 hu/sq.mi.[19]

If the Baseline Module's input data had been more varied, the Nebraska Companies would not have such strong reservations about the reliability of the outputs. Particularly troubling is the apparent scarcity of input data from very low density census blocks that are common in Nebraska and other high plains and western states. Housing unit density, as discussed in detail later, is a significant factor when determining the cost to provide broadband service. As a statistical matter, it is very difficult to reliably predict behavior at the extreme end of a continuum when one's sample has few, if any, cases in the predicted range. The Nebraska

[18] U.S. Census Bureau, 2000 Summary File 1: Geographic Comparison Tables, http://www.census.gov.

[19] *Id.*

Companies conclude that the Baseline Module results have not been meaningfully validated for conditions in Nebraska or in other similarly situated states.

2. Availability Outputs for Nebraska Are Not Reliable

The Nebraska Companies have compared the Nebraska availability predictions provided in the Model against Nebraska broadband availability data drawn from other sources. In one study, the Nebraska Companies attempted to collect broadband information regarding the four counties in Nebraska in which the Consolidated Companies[20] serve a sufficient portion of the county as the incumbent LEC for a reliable comparison to be made.[21] In those counties, the *Vantage Point Study* determined the number of customer locations at which Consolidated Companies' distribution network is capable of providing broadband at the 4/1 Mbps standard.[22]

The Nebraska Companies compared the resulting ratios against the Model information.[23] The results of this comparison are shown in the following table.

County	Actual 4/1 Mbps Availability	Model Estimated Availability	Approximate Percentage Difference
Blaine	62%	21 to 30%	Underestimated by 30%
Grant	58%	41 to 50%	Underestimated by 10%
Hooker	79%	71 to 80%	No Difference
Thomas	72%	41 to 50%	Underestimated by 20%

[20] The Consolidated Companies are a group of affiliated incumbent local exchange carriers with service areas located in the State of Nebraska and consisting of: Consolidated Telephone Company, Consolidated Telco, Inc., Consolidated Telecom, Inc., and The Curtis Telephone Company.

[21] In each of these four counties, the Consolidated Companies provide service to 95% of the counties' customer locations.

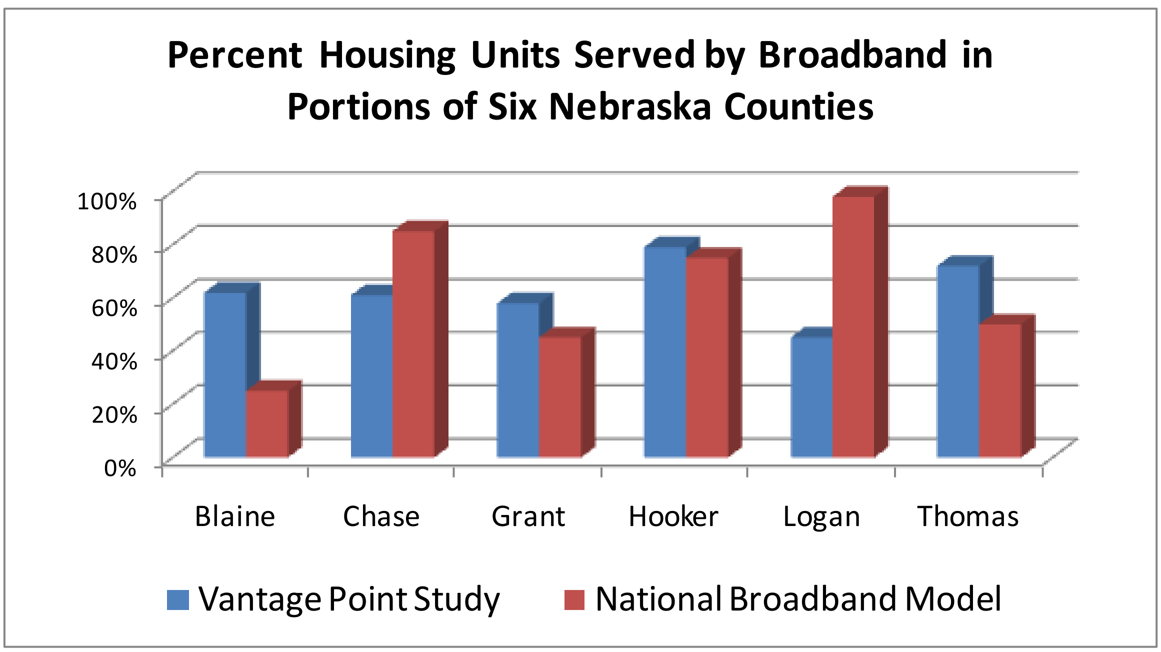
[22] These subscriber counts are based on access line counts; therefore, business lines are included, but housing units that do not subscribe to telephone service are excluded. To ensure the reliability of this data, the Consolidated Companies counted locations within Blaine County and found the resulting availability to be within 5% of that determined using access line counts. As such, access line counts were determined to be an adequate proxy.

[23] Model data were derived from files available at the Commission's web site and at the U.S. Census Bureau web site. The data are graphically displayed in *Broadband Gap Paper*, p. 18, Ex. 2-B.

Great Plains Communications, Inc. ("Great Plains") commissioned Vantage Point to perform a similar study of several Great Plains study areas. The study sample was limited to two counties for which the Great Plains service area covers a large portion of the county. The following table shows the study results.

County	Actual 4/1 Mbps Availability	Model Estimated Availability	Approximate Percentage Difference
Chase	61%	81 to 90%	Overestimated by 20%
Logan	45%	96 to 100%	Overestimated by 50%

The following chart illustrates the combined Consolidated and Great Plains results graphically.[24]



In sum, the Model understated broadband availability in three of the six counties sampled. Moreover, there were large differences between the study and the Model estimates of

[24] The chart uses the midpoint of the range shown in the preceding table for the Model value.

broadband availability. In only Grant and Hooker counties can the estimates be considered reasonably comparable.

It is important to note that the preceding study reflects the capacity of the existing distribution network to *support* 4/1 Mbps standard service, not whether 4/1 Mbps standard service is *currently offered* to retail customers. Since the Commission uses the National Broadband Plan Model to estimate the incremental cost of expanding the existing network, network facilities are the relevant input variable for the Cost-To-Serve Module.[25]

In conclusion, the Nebraska Companies' facilities-based studies across six Nebraska counties found that the National Broadband Plan Model does not reliably predict existing broadband coverage. In some cases, the Model predicted too much broadband coverage, but in most cases it predicted too little coverage. The average error is large. Using correct information for these counties would very likely change the calculation of the counties' investment gaps, and it might change the Commission's final judgment about the nature of the least-cost technology.

C. The Cost-To-Serve Module Does Not Accurately Predict Costs

The Cost-To-Serve Module constructs virtual networks that could serve census blocks that were identified as not currently served by broadband service at the 4/1 Mbps standard. This virtual network is an "augmentation" network, meaning that it augments the existing network, building out from assumed existing facilities.[26] Outputs are calculated by census block. For

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[25] The Model assumes that if broadband service at the 4/1 Mbps standard is not currently being provided, the network is incapable of such service. In fact, even when appropriate infrastructure is in place, carriers may not provide service at maximum speeds in order to economize on middle mile and backbone connections. This situation is especially common for small rural carriers who exert little market power in connection with the purchase of middle mile and backbone facilities even though these rural carriers' traffic frequently involves long transport distances. The effect of these operating costs is discussed below in more detail.

[26] *Model Documentation Paper*, p. 9.

each census block the Module produces a series of cost figures, including several categories of investment and operating expenses.[27]

The Cost-To-Serve Module can be run for wireline technology or for wireless technology. Each method uses different inputs and different assumptions. In preparing the base case scenario, the Commission ran the Model both ways, producing cost output files for both wireline and wireless technologies. Later, these results were compared by the Assessment Module.

The Nebraska Companies also commissioned Vantage Point to evaluate the accuracy of National Broadband Plan Model's Cost-To-Serve Module. Vantage Point studied four Nebraska exchanges operated by Great Plains that were selected to reflect the diversity of customer density and other factors typical of rural Nebraska. Vantage Point produced both wireline and wireless broadband network designs for these exchanges, using various design parameters. Vantage Point then compared its own inputs and results to the inputs and results set forth in the National Broadband Plan Model. Vantage Point also reviewed the costs of Consolidated Companies' network upgrade. More design details and findings are discussed below.

1. The Cost-To-Serve Module Does Not Reliably Estimate Wireline Costs

a. The Cost-To Serve Module Does Not Reflect the Capabilities of Some Existing Distribution Networks

The wireline Cost-To-Serve Module improperly assumes that areas currently unserved at the 4/1 Mbps standard require extensive new construction to provide that service. The reality is far more complex. The Cost-To-Serve Module fails to identify existing infrastructure that can be

[27] *Id.*, pp. 8-9.

incrementally upgraded at modest cost to provide service at the 4/1 Mbps standard. The Cost-To-Serve Module therefore overstates wireline costs in these areas.

The Nebraska Companies assert that, in rural areas, the reason that a wireline carrier fails to provide broadband service at the 4/1 Mbps standard today is often not due to insufficient distribution facilities. Rather, the prime reason is the unacceptably high recurring cost of middle mile transport and backbone connections. The Consolidated Companies purchase backbone Internet service from three different carriers at between $121 and $177 per Mbps per month. This is an order of magnitude larger than the charges in Omaha, the largest city in Nebraska, where carriers pay a mere $10 to $20 per Mbps per month.[28] Small rural carriers have little market power to negotiate reasonable rates, and frequently have long transport distances, therefore causing such carriers to be disproportionately affected by middle mile and backbone costs.

Some of these rural carriers have highly capable distribution networks, but lack only some relatively inexpensive electronics in remote (DLC) cabinets to reach the 4/1 Mbps standard. To illustrate these points, the Nebraska Companies offer information from the *Vantage Point Study* that concerns the Consolidated Companies*:*

- Consolidated offers broadband Internet service meeting the 4/1 Mbps standard to 76% of its subscribers.[29]
- If Consolidated were to upgrade its electronics in DLCs at a cost of $500,000 or $690 per additional location, Consolidated could offer 96% of subscribers in the

[28] *Vantage Point Study*, p. 53.

[29] *Id.*, p. 53.

northern half of its service territory with broadband service meeting the 4/1 Mbps standard.[30]

Consolidated has not installed those additional hardware upgrades because Consolidated cannot acquire adequate middle-mile facilities at rates that make a positive business case for offering service at the 4/1 Mbps standard.

b. Wireline Cost-To-Serve Outputs for Nebraska Are Not Reliable

Vantage Point prepared detailed network designs and engineering estimates to determine the investment required to offer various levels of wireline broadband service. The studies covered four exchanges operated by Great Plains. In each exchange, Vantage Point created an engineering estimate of the incremental costs of providing service to unserved areas within the exchange at the 4/1 Mbps standard. Vantage Point then mined the comparable National Broadband Plan Model investment data from the Commission's published data sheets, which list investment on a county basis. Vantage Point allocated that investment to the covered exchange using an area allocator. The resulting data are replicated in the table below showing the two estimates of costs of DSL service at the 4/1 Mbps standard:[31]

Wireline Costs – Investment per Unserved Location			
Exchange	**NBP Model**	**Vantage Point Study**	**Ratio**
Verdigre	$ 6,900	$9,300	1.3
Stapleton	$ 2,100	$7,600	3.7
Gordon	$ 5,600	$9,000	1.6
Imperial	$ 4,300	$3,000	0.7

[30] *Id.*, p. 54, Table 5-1.

[31] *Id.*, p. 58, Table 6-5. The "Ratio" column calculates investment based upon the Vantage Point Study investment divided by the investment from the NBP model.

The *Vantage Point Study* concludes that the National Broadband Plan Model did not accurately estimate the necessary wireline investments. Vantage Point did not discern a consistent pattern of error – the ratios range from 0.7 to 3.7. In one county, the Model's estimates were significantly too high, while in the other three cases the estimates were significantly too low.[32]

2. The Cost-To-Serve Module Does Not Reliably Estimate Wireless Costs

a. The Model's Network Loading Analysis Will Not Provide Comparable Wireless Service and Inappropriately Favors Wireless Technology

The Commission's calculations of the capacity of wireless networks overestimate the capacity of wireless networks to provide consistent and reliable broadband service at the 4/1 Mbps standard. By comparing wireline technologies that can *always* provide 4/1 Mbps standard service to every customer with wireless access network technologies that can only *sometimes* provide 4/1 Mbps standard service, the analysis is inherently flawed in a way that favors wireless technologies. It also endorses a network design that is unlikely to provide adequate service.

The Commission found that the average broadband wireless network user will have a mean "Busy Hour Offered Load" ("BHOL") of 444 kbps in 2015.[33] This is the expected network demand by typical customers during the busy hour on the average day in 2015. A wireless network constructed to meet this capacity would be highly likely to offer 4 Mbps to its users at any time during that mean day. It would not, however, be able to meet the demand on busier days, such as the busiest hour on the busiest day of the year. On any day where demand rises above the mean busy hour, the users would not receive 4 Mbps service.

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[32] *Id.*, p. 58.

[33] *Broadband Gap Paper*, p. 113.

The Nebraska Companies question whether an average load of 444 kbps is an appropriate starting point for a design analysis aiming to provide broadband service at the 4/1 Mbps standard. If the electric grid were constructed using the same reasoning, it would be at full capacity on the busy hour during the average day. On many days the electric grid experiences a load peak hour that substantially exceeds the peak on the average day. Accordingly, electric grids are typically constructed with a reserve capacity well above the peak hour demand on the average day. An electric network designed to the equivalent of 444 kbps would therefore have brownouts or blackouts on almost every summer afternoon when peak loads exceed the average day.

The Cost-To-Serve Module did not assume a BHOL of 444 kbps, but of 160 kbps, further limiting the likelihood of customers obtaining 4 Mbps at any but the least busy times. The Commission never offered a plausible reason for this reduction that reduced the cost outputs of the Cost-To-Serve Module for wireless networks. The following table summarizes what appear to be the relevant facts. To account for demand growth, the 2015 values are four times the 2009 values, reflecting an annual 26% rate of growth.[34]

BHOL Assumptions			
Peak Hour Demand	***2009 kbps***[35]	***Annual Growth***	***2015 kbps***[36]
All Users	92-111	26%	370-444
Bottom 90% of Users	36-43	26%	144-173

[34] *Id.*, p. 111. The Commission assumed that demand is doubling every three years. The implied annual demand growth factor used here is 26%.

[35] *Id.*, p. 111, 112 Ex. 4-BR.

[36] *Id.*, p. 113 Ex. 4-BS.

From the range of 144-173 kbps in the bottom right cell, the Commission apparently selected 160 kbps, which is near the midpoint. The Commission concluded that this design parameter will "support the traffic of the overwhelming majority of all user types, including the effect of demand growth over time."[37]

The Commission has not offered any rational basis for this decision. The 160 kbps assumption is apparently based on simply excluding the top 10% of users (and 65% of the load) from the network. The only way this estimate might be acceptable is if those heavy 10% users know when the network busy hour occurs and, for some reason, elect to shut down their Internet usage during that period. The probability of such an occurrence is essentially zero. No known traffic management technique imposes a similar limitation. Therefore, based on the Commission's own analysis, a network designed to provide a BHOL of 160 kbps will not be able to regularly deliver broadband service at the 4/1 Mbps standard to its customers.

The Commission's BHOL discussion repeatedly cites work done by AdTran.[38] AdTran recently filed a technical memo indicating that the Commission's BHOL assumption "creates a bias towards limited capacity, shared access technologies such as FWA, and may have materially affected the conclusions" of the *Broadband Gap Paper*. [39] AdTran noted that it is improper "to exclude the heaviest users if your goal is to provide broadband available to all."[40]

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[37] *Id.*, p. 111.

[38] *Id.*, pp. 111, 124-26, notes.74, 75, 79, 131, 152, 158 and 161.

[39] AdTran *ex parte* dated May 28, 2010, filing confirmation No. 2010528853839 ("*AdTran Filing"),* p. 1.

[40] *Id.*, p. 2.

AdTran also found another problem. The Model assumed that each cell site served with 2 x 20 MHz channels would have a capacity to serve 650 people.[41] AdTran criticized this value. Even assuming the Commission's BHOL of 160 kbps, AdTran calculated the maximum capacity of such a cell at 456 users.[42] If the Model were to use a more reasonable BHOL of 444 kbps, AdTran estimates the capacity of that 2 x 20 cell tower at 110 to 140 customers, not 650.[43]

A service provider that offers broadband service at the 4/1 Mbps standard can achieve a BHOL of 444 kbps using an "oversubscription ratio" of 9:1. This means that the service provider can sell 9 Mbps of capacity for every 1 Mbps of actual capacity. It also means that if all users attempt to access the network at the same time, each user will receive 444 kbps of capacity. When the BHOL is lowered to 160 kbps, the oversubscription ratio rises to 25:1.

The Commission's own analysis also demonstrates the inadequacy of its target BHOL of 160 kbps and the associated oversubscription ratio of 25:1. Exhibit 4-BT of the *Broadband Gap Paper* shows the likelihood that a customer being served by a broadband facility serving 100 subscribers can achieve a burst rate of 4 Mbps at varying oversubscription ratios.[44] The exhibit shows, for example, that a customer with an oversubscription ratio of 17:1 has a 90% chance of achieving a speed burst of 4 Mbps. In other words, this customer will likely receive the bandwidth he or she has paid for 90% of the time.

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[41] *Broadband Gap Paper*, pp. 61 and 126, note 160.

[42] *AdTran Filing*, p. 3.

[43] *Id.*, p. 3.

[44] *Broadband Gap Paper*, p. 113. Exhibit 4-BT discusses the behavior of wired and satellite links, not wireless links. There is no separate discussion of the behavior of wireless links in the paper, although the Commission appears to have relied on this exhibit in establishing the wireless BHOL of 160 kbps.

When the oversubscription ratio is changed to 25:1, the same customer's probability of getting the advertised speed drops to approximately 18%.[45] In other words, if a customer is served by a 100-subscriber tower in a network designed in accordance with the Cost-To-Serve Module with 25:1 oversubscription, the customer has an 82% chance of getting less than what was promised. This service could not legitimately be said to meet the 4/1 Mbps broadband service standard.

Of even more concern in the *Broadband Gap Paper* is the network performance deterioration in small installations. Exhibit 4-BT shows a large difference between the performance of a network with 100 subscribers as compared to a network with 500 or 2,500 subscribers. It appears that larger networks have more stable demand, and small installations are particularly sensitive to demand fluctuations. At a given oversubscription ratio, network performance drops as the number of subscribers decreases. A small number of subscribers per antenna is highly likely in rural areas with low subscriber densities. With only a few subscribers on a cell tower, a 25:1 oversubscription ratio may produce especially poor performance in the remote areas that are the intended targets of federal universal service funds.

Another way to understand the oversubscription problem is to consider the capacity of a typical wireless installation with 10 MHz (two 5 MHz channels) of spectrum. With a downstream spectral efficiency of 1.5 bps per Hz of spectrum, the provider would have a downstream capacity of only 7.5 Mbps. At a 25:1 oversubscription ratio, the wireless provider could serve 46 customers at this site,[46] yet the bandwidth is insufficient to support even two

[45] *Id.* This value has been estimated visually.

[46] 7.5 Mbps * 25 / 4 Mbps = 46.9 subscribers.

users at 4 Mbps.[47] If only one subscriber consumes 4 Mbps, the remaining 45 users must share the remaining 3.5 Mbps.

A user may not notice a loss of service quality if the user's applications are "bursty" and the applications are not time-sensitive. However, today's broadband users meet neither of these criteria. Broadband usage increasingly requires support for media streaming, such as is used for remote medical procedures, teleconferencing, and surveillance video. In addition, audio and video media transmission is consuming a larger portion of Internet capacity. These kinds of applications consume significant amounts of network capacity for extended periods. Similarly, many applications on the broadband network are time sensitive, such as teleconferencing and VoIP. As network usage patterns shift, the inadequacy of a 25:1 oversubscription network is likely to become even more apparent over time. The BHOL design parameter should be increased over time to maintain acceptable network performance.

The Nebraska Companies are also concerned that the National Broadband Plan Model's design for wireless networks may not have sufficient capacity for reliable emergency communications, including provision of voice dial tone in an emergency and transmitting a timely 911 message. In a future NOI, the Commission should specifically ask whether and under what circumstances a wireless network with a BHOL of 160 kbps and an oversubscription ratio of 25:1 can reliably deliver emergency voice services.

In conclusion, the Model's assumptions regarding wireless capacity do not appear capable of meeting the Commission's announced goal of delivering a "robust broadband

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[47] Assuming an unlikely fourfold increase in spectrum available (two 20 MHz channels) produces 30 Mbps of total capacity, which would still only allow seven users to demand 4/1 Mbps concurrently.

experience" at the 4/1 Mbps standard.[48] Moreover, the faulty assumptions reduce the apparent cost of meeting the broadband gap with wireless facilities, thereby casting doubt on the Commission's conclusion that wireless technology is the least costly solution to the broadband gap in much of the country.[49] AdTran concluded that using a BHOL of 444 kbps to 554 kbps is a reasonable projection of network behavior in 2015.[50] Whatever BHOL the Commission ultimately adopts, the value should be high enough to ensure that rural customers have broadband service at the adopted standard at least 90% of the time, even when a customer's cell tower provides service to very few locations.

b. The Commission's Wireless Analysis Inappropriately Departed from Its Usual Practice of Relying Only on Proven Technologies and Installed Facilities

As a general policy, the Commission decided that a technology must be "commercially deployable to be considered part of the solution set"[51] and must be "capable of providing carrier class broadband."[52] Furthermore, the Cost-To-Serve Module generally relied on existing facilities to estimate the incremental cost of upgrading the network. The Commission's analysis in the *Broadband Gap Paper* broke both of these rules with regard to 4G service.

First, the Commission assumed that 4G service will prove to be a reliable service with known propagation characteristics and that it will generate "substantive cost savings."[53]

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[48] *Id.*, p. 111.

[49] *See Id.*, p. 12, Ex. 1-I.

[50] *Id.*

[51] *Id.*, p. 2.

[52] *Id*.

[53] *Id.*, p. 65.

> [T]he model only includes technologies that have been shown to be capable of providing carrier class broadband. While some wireless 4G technologies arguably have not yet met this threshold, successful market tests and public commitments from carriers to their deployment provide some assurance that they will be capable of providing service.[54]

The Commission also explained that it relied on the "superior performance" of 4G systems when estimating the size of the National Broadband Gap.[55]

LTE wireless networks have not yet been demonstrated to possess the capabilities to reliably provide end user broadband services at the required 4/1 Mbps speeds and service quality. The *Broadband Gap Paper* acknowledges that the LTE product for 4G wireless is not yet commercially deployed, and "it is conceivable that actual downlink spectral efficiency and, consequently, subscriber capacity differ from that simulated."[56] It is extraordinary for the Commission to presuppose that an untested technology will succeed, particularly in the light of some past experiences with technologies that failed to measure up to expectations.

The two existing 4G technologies, WIMAX and LTE, are anything but proven workhorses. The Commission has acknowledged technological difficulties that historically delayed deployment of WIMAX as well as the fact that LTE is a new technology that has not yet been deployed commercially on a wide scale.[57] AT&T is conducting trials of LTE this year.[58] The basis for the Commission's assumption that 4G will succeed in meeting the task of providing carrier class broadband is unclear. In Section IV.A below, the Nebraska Companies advocate that the Commission should establish rigorous service quality standards for supported

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[54] *Id.*, p. 2.

[55] *Id.*, p. 65.

[56] *Id.*, p. 78.

[57] *Id.*, p. 28.

[58] *Id.*, p. 65.

broadband services, and it is far from clear at this point that 4G service, in general, will satisfy an appropriate set of service quality requirements, particularly in sparsely populated areas such as much of Nebraska.

Second, the Commission established the 4G service map, not based on installed facilities, but based on announced deployment plans from major carriers.[59] These plans included Verizon's announced intention to build LTE into 20 to 30 markets in 2010, AT&T's announcement that it will deploy LTE commercially in 2011, and Sprint/Clearwire's announcement that it will cover 120 million people by the end of this year.[60] The Commission then asserts that it relied on the resulting "likely extensive" 4G coverage by 2013 in its financial analysis.

These two departures from normal practice were unjustified. When planning national programs, the Commission certainly has discretion to select reasonable assumptions. When the output of those analyses is limited to budgetary matters such as the size of the broadband gap, systematic errors may produce minimal harm, possibly none. However, these errors could cause substantial harm if the Model in its present form is used as the basis for distributing USF support.

c. The Model Makes Inappropriate Assumptions about Tower Availability That Improperly Favor Wireless

The *Broadband Gap Paper* contained assumptions about the availability of towers necessary to provide broadband service. One such assumption was that for areas where no tower is shown in existing data sets, a new tower will need to be constructed only 52.5% of the time. For the remaining 47.5% of the time, the Cost-Of-Service Module assumes that a cell site can be

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[59] *Id.*, pp. 64-65 and 130.

[60] *Id.*, p. 65.

"located on an existing structure (e.g., a grain silo or a church steeple)." [61] Overall, the Cost-Of-Service Module assumes that a new tower is needed around 15% of the time.[62]

The Nebraska Companies submit that the Model's tower build parameters are not even close to reality for rural Nebraska. It is much more likely to be true in Nebraska that a new tower *is not needed* 15% of the time than that a new tower *is needed* 15% of the time. The geographic and demographic characteristics of Nebraska, particularly regarding its western half, make the chances far less than even that a wireless carrier in rural Nebraska can find a grain silo or church steeple to which it can attach a needed broadband antenna.

The *Vantage Point Study* examined this question in four Nebraska exchanges. Vantage Point first examined the new towers that would be needed in those exchanges to provide 160 kbps BHOL service. The results are shown in the following table:

Tower Construction For 160 kbps BHOL LTE Service			
Exchange	**Required New Sites**	**New Towers Needed**	**Percentage New Towers**
Verdigre	1	0	0%
Stapleton	3	2	67%
Gordon	7	6	86%
Imperial	8	5	63%
Total	**19**	**13**	**68%**

Vantage Point then examined the same issue, but for a more reasonable BHOL assumption of 444 kbps. The results are shown in the following table:

[61] *Id.*, p. 81.

[62] *Id.*, p. 82.

Tower Construction For 444 kbps BHOL LTE Service			
Exchange	**Required New Sites**	**New Towers Needed**	**Percentage New Towers**
Verdigre	2	0	0%
Stapleton	7	6	86%
Gordon	20	19	95%
Imperial	19	19	100%
Total	**48**	**44**	**92%**

Even at 160 kbps, more than two-thirds of the new towers needed require new construction. At the higher BHOL appropriate for current demand, 92% of sites required new construction. These results simply cannot be reconciled with the Model's conclusion that new towers are only needed 15% of the time.

As a source for these parameters, the *Broadband Gap Paper* cites a single Clearwire *ex parte* presentation to the Commission in November of 2009.[63] This new tower parameter strongly affects the apparent relative desirability of providing support to wireline versus wireless carriers. No such critical parameter should be set solely on the basis of a single *ex parte* presentation. A future NOI should seek comment on this important modeling parameter. As matters stand now, the Cost-To-Serve Module clearly understates wireless tower construction cost and creates an unwarranted competitive advantage for wireless providers.

d. Bandwidth is a Scarce Resource Generally Held by Large Carriers

As the Commission properly recognized, spectrum limitations are a constraint on wireless broadband availability.[64] Entry into the wireless broadband market is limited by this resource.

[63] *Id.*, p.124, note 68.

[64] *See generally*, *National Broadband Plan*, § 5.4.

The *Broadband Gap Paper* contained some sample calculations of wireless service providers' use of bandwidth. The typical scenario contemplated in the *Paper* was a carrier with two 20 MHz blocks of spectrum.[65] This assumption is unrealistic, given the historical results of 700 MHz bandwidth spectrum auctions. A more plausible scenario would be a carrier with two 5 MHz bands.[66] That reduced spectrum, however, would mean that fewer subscribers could be served per tower. Some large wireless carriers do hold 40 MHz of spectrum in selected areas. While smaller carriers do hold some spectrum, their holdings are generally more limited than that required for a fully functioning fixed wireless broadband system.

Therefore, large national carriers such as Verizon tend to be the only carriers likely to hold enough spectrum to have a reasonable chance of providing satisfactory broadband service. To the extent that wireless is found to be the least-cost alternative, large wireless providers would have a greater chance of qualifying for support.

e. The Model Makes Inappropriate Spectral Efficiency Assumptions That Improperly Favor Wireless

The *Broadband Gap Paper* assumed that a wireless LTE network could operate at a spectral efficiency of between 1.36 and 1.5 bps/Hz.[67] The *Paper* also explained that the theoretical maximum for LTE is approximately 1.8 bps/Hz.[68]

The *Broadband Gap Paper* does not specify the spectral efficiency parameter that was actually used by the Cost-To-Serve Module, but it does state the number of customers that can be

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[65] *Id.,* p. 61.

[66] For cost modeling purposes, Vantage Point assumed that 2x5 MHz bands were available to a wireless provider at no investment cost. Subsequent bands of 5 MHz spectrum were assumed to impose an investment cost. This assumption favors wireless carriers by understating spectrum costs that have been subject to auction.

[67] *Id.,* Exhibit 4-E, p. 64.

[68] *Id.,* p. 64.

served from a given spectrum allocation.[69] Vantage Point calculated that the Model must have used a spectral efficiency parameter of 1.92 bps/Hz.[70] This value is higher than the theoretical maximum. In reality, an LTE system could only provide a portion of this capacity.[71] The net effect of this high spectral efficiency parameter is to allow a smaller network to serve more customers and thereby to understate the cost of an LTE network.

f. Wireless Cost-To-Serve Module Outputs for Nebraska are Not Reliable

The wireless outputs of the Cost-To-Serve Module are not reliable estimates of the incremental investment actually needed to provide wireless broadband service meeting the 4/1 Mbps standard in Nebraska. Vantage Point prepared engineering estimates of the costs that would be incurred to provide broadband service at the 4/1 Mbps standard in four Nebraska exchanges operated by Great Plains. To match areas, Vantage Point scaled county investment to the exchange level based on relative surface areas. Vantage Point then compared those estimates to the cost estimates produced by the Cost-To-Serve Module. The results are shown in the following table.[72]

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[69] *Id.*, pp. 60-61.

[70] The *Broadband Gap Paper* calculated that with 2 x 20 MHz of spectrum (20 MHz for upstream and 20 MHz for downstream) and a three sector cell site, the cell site can serve 650 subscribers. The paper also states that 29% to 37% of these customers (188 to 240 customers) could simultaneously obtain a 460 Kbps video stream. For that to be possible, between 90.24 and 115.2 Mbps of capacity would have to be available, which would require a spectral efficiency of 1.92 bps/Hz. *Broadband Gap Paper,* pp. 60, 61 and 126 note 160.

[71] Using actual LTE spectral efficiencies, only 81.6 to 90 Mbps of capacity will be available, so only 170 to 187 customers (not 188 to 240 customers) would be able to enjoy a 480 kbps video stream simultaneously. *Vantage Point Study,* p. 7.

[72] *Id.*, Table 6-5, p. 58.

Wireless Costs - BHOL = 160 Kbps (25:1 Oversubscription)			
Exchange	**National Broadband Plan Model Investment Per Unserved Location**	**Vantage Point Study Investment Per Unserved Location**	**Ratio**
Verdigre	$ 3,600	$ 6,900	1.9
Stapleton	$ 800	$ 6,300	7.9
Gordon	$ 3,000	$ 6,000	2.0
Imperial	$ 1,700	$ 4,500	2.6

In all four cases, the National Broadband Plan Model substantially understated the actual investment needed for 25:1 oversubscription wireless service. In the Stapleton Exchange, the difference was very large, with the National Broadband Plan Model understating actual investment by a factor of eight. In sum, the National Broadband Plan Model did not accurately estimate the necessary wireless investments, even for a minimal 25:1 network that, as explained above, cannot reliably provide 4/1 Mbps service.[73]

3. Density is the Primary Driver of Cost Per Customer

In Attachment B, the Nebraska Companies provide a detailed description of the Nebraska Universal Service Fund ("NUSF"). A unique feature of the NUSF is that it uses customer density per square mile as a proxy for cost. The Nebraska Public Service Commission (the "Nebraska Commission") originally established the relationship to cost by running a cost model once and then performing a regression analysis against density. Since that original study, the Nebraska Commission has distributed support as a function of customer density in the served area. The NUSF routinely calculates support amounts without running any cost model.

[73] *Id.*, pp. 6 and 58.

The Nebraska Companies suggest that the Commission consider using a similar methodology for CAF support. Using density as a primary indicator of support needed could greatly simplify the burden of calculating costs. It also has inherent appeal, since the public is more likely to accept support that is driven by density and potentially a few other factors than to accept support that is driven by the outputs of a complex model for which data have not been fully released and that cannot be replicated outside the FCC.

For a national program, it may be desirable to add additional geographic variables. Nebraska's geography and climate is relatively uniform, at least as compared to the nation. To fully reflect cost, it may be better to incorporate some additional variables such as terrain ruggedness, soil depth and composition or average temperature.

Density is increasingly able to predict costs as economics shift overall network costs away from electronics and toward cables, wires and poles. As electronics costs fall, such costs assume less and less importance over time as a portion of overall network investment.

The density proxy has worked well in Nebraska and is widely accepted. The Commission should consider density along with a few of the other factors discussed above as an alternative to complex cost models.

D. The Demand and Revenue Module

The Demand and Revenue Module first estimates incremental demand and revenues associated with data, voice and video services delivered over the modeled technology. Then, the Module estimates revenue as a function of average revenue per user and take rates, each of which in turn is modeled based on demographic data.[74]

[74] *Model Documentation Paper*, pp. 9-10.

1. Support Should Be Based on Costs and Revenues

The *NOI* sought comment on whether the Commission should consider revenues, as well as costs, in determining CAF support.[75] The National Broadband Plan recommends that support should be based on the net broadband investment gap (i.e., forward-looking costs less revenues) and that the revenues should include all revenues earned from broadband-capable network infrastructure.[76] The Nebraska Companies agree as a general principle that CAF support should be calculated based on consideration of both revenues and costs.

2. The Revenue Module Should Consider Actual Revenues from Some but Not All Unregulated Services

The *NOI* also sought comment on the kinds of revenues that should be considered, specifically including Internet and video revenues.[77] The Nebraska Companies recommend that the revenues calculation include a term for revenues actually derived from the provision of broadband Internet service. This service is now offered by most incumbent LECs. Moreover, as the NBP shows, broadband is of increasing importance to the nation. It is particularly important to count *actual* revenues in an environment when competing carriers, some of whom may be subsidized by government grants or subsidies of their own, are splitting the market with supported carriers.

On the other hand, video revenues should be disregarded in making a support calculation, notwithstanding the recommendation of the National Broadband Plan.[78] Rural video services typically are losing money today, primarily due to high programming costs. If

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[75] *NOI,* para. 35.

[76] *Id.,* para. 36.

[77] *Id.,* paras. 36-37.

[78] *National Broadband Plan,* p. 145.

the Commission includes video costs and revenues in its support calculation, the effect will be to further increase the already significant demands on USF funds.

If video revenues are not included, then a portion of costs associated with video should also not be included. Excluded costs should include programming, video head-end equipment and a portion of the last-mile facility. Since video services share last-mile facilities with broadband Internet service, the Nebraska Companies recommend that the Commission develop cost allocations to "carve-out" a portion of last-mile costs associated with video. By excluding both video costs and revenues, the Commission can avoid the complexities that would otherwise be required in estimating multiple tiers of video revenues and multiple combinations of content costs associated with basic programming, pay-per view channels, premium programming, HDTV, and video-on-demand. More importantly, by excluding video revenues and costs the Commission will not increase the investment gap and increase the need for federal resources.

3. Revenues Should Be Estimated Primarily From Actual Rates and Actual Subscribership

The *NOI* seeks comment on how revenues should be estimated in a future support calculation, especially considering the fact that different services may be available in different parts of the country, and prices may vary in different areas.[79] The Nebraska Companies recommend that for support calculations, broadband Internet service revenues should be equal to the rate actually charged by the broadband provider for access to the Internet, multiplied by the number of actual subscribers. Where a rate includes the delivery of some content, that rate should be reduced proportionally to exclude the portion related to content.

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[79] *NOI,* para. 37.

To avoid creating undesirable incentives, the Commission could investigate whether it is appropriate to have some constraints on the revenue estimate used for the support calculation.

- A minimum or "floor" rate for broadband Internet access would eliminate the possibility that support could create an incentive to offer extremely low subscriber rates. If Lifeline customers are able to purchase service below the floor rate, such rate should not apply to such customers.
- A minimum or "floor" take rate[80] would give service providers a financial incentive to keep take rates at or above that minimum level in areas where qualifying broadband Internet service is offered.

Using the broadband Internet rates actually charged by carriers is a better approach than using a fixed national "benchmark" value. Income disparities and other demographic factors make a single national figure too inflexible. An affordable rate in Connecticut may be well beyond the affordability level for a farmer in rural Nebraska. A nationally uniform monthly broadband Internet rate would likely reduce support in low-income areas and thus would be more likely to violate the affordability standard.

If the Commission nevertheless wishes to use a revenue model to estimate the rates charged for broadband Internet service, that model should be sensitive to household income in the area supported. In addition, the Commission should review its forecasted revenues model periodically and adjust the revenue parameters based on current revenue conditions.

E. The Assessment Module

The Commission has explained that the Assessment Module pulls together the cost and revenue outputs from the previous modules and calculates a "gap" for each "market area." For

[80] The take rate would apply to areas served by the provider's broadband Internet service, which might be smaller than its voice service area.

the National Broadband Gap estimate, that "market area" was the county. The Model also "levelizes" the cost and revenue inputs so that outputs are comparable values expressed as net present values ("NPV"). [81]

The Nebraska Companies' comments in this section summarize and analyze the concerns stated above. While the prior comments included additional facts based on the *Vantage Point Study*, the comments below are policy-oriented and articulate conclusions that are based on the above findings.

1. Errors in Outputs from Earlier Modules Make Assessment Module Outputs Unreliable

The National Broadband Plan Model documentation discusses the many detailed input sources used in the National Broadband Plan Model. It notes, for example, that demographic, geographic and communications infrastructure detail has been collected for 8.2 million census blocks and that the Model replicates "real-world engineering practices."[82] While the Model contains considerable detail in its inputs, the Nebraska Companies are not aware that the Commission has tested the reliability of the outputs as a whole. Even if the component elements of a complex model are themselves reliable, it does not follow that the final result of the entire model is reliable.

As the comments above demonstrate, not all of the underlying elements of the National Broadband Plan Model are reliable. The problems include unreliable estimates of broadband availability as well as several cost parameters that are strongly biased to reduce apparent wireless costs. These problems create serious doubt as to the accuracy of the Commission's published

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[81] *See generally, Model Documentation Paper*, p. 10.

[82] *Id.*, pp. 5-6.

National Broadband Gap figure, as well as the ability of the National Broadband Plan Model eventually to serve a role in calculating support.

The Commission should not assume that all Model errors will cancel. To the contrary, in a multistage calculation like the National Broadband Plan Model, later errors can compound early errors, leading to a large final error. The Nebraska Companies offer an example involving the interaction of only two of the several errors described above.

- The Baseline Module declares that areas are either served or unserved. In unserved areas, the Cost-To-Serve Module incorrectly assumes that distribution facilities must be constructed to extend existing facilities. The effect in some areas is to overstate the cost of providing wireline broadband service.
- The Cost-To-Serve Module incorrectly allows wireless networks to be built at an oversubscription ratio of 25:1. This substantially reduces the cost of providing wireless broadband service.

The combined effect of these errors casts grave doubts on conclusions in the *Broadband Gap Paper*, such as Exhibit 1-I which purports to show that the great majority of the counties east of the Rocky Mountains can receive wireless broadband as the "lowest-cost technology."[83] Since the Commission's calculations overstated wireline cost and understated wireless costs, the area where wireless is truly the lowest cost technology is almost certainly smaller than the area shown in Exhibit 1-I.

The combined effect of these two errors could also affect future support distributions.

- If the Assessment Module's gap outputs were used to calculate formulaic support, the amount of support would be either too large or too small, regardless of

[83] In Nebraska, six counties are shown as fully served and four counties are shown as best served by wireline. The remaining 83 Nebraska counties are shown as capable of being served at lowest cost by wireless.

whether the Assessment Module relies on lowest cost technology or second-lowest cost technology.

- If the Assessment Module's gap outputs were used to set a reserve price for an auction, either the reserve price would be higher than is necessary (thereby wasting USF funds), or the reserve price would be set too low (thereby producing no bidders).

Before the Commission uses the Model for support distributions, it should undertake an evaluation of the assumptions underlying the Model and should obtain independent tests of the reliability of its outputs, including availability of broadband, the extent of existing facilities, and the capex and opex costs of both wireline and wireless technologies.

2. The Assessment Module Produced Inaccurate Outputs Because of Two Additional Methodological Errors

The Commission's estimate of a national investment gap of $23.5 billion was flawed for two additional reasons, as described below.

a. The Gap Estimate Was Based on Second-Lowest Cost

The Commission's National Broadband Gap estimate is based on summing for each geographic area the second-lowest gap technology.[84] Game theorists considering the likely behavior of bidders at an auction predict a final price equal to the second-lowest cost when there are two or more bidders who know the others bidders' costs.

By using second-lowest cost to estimate the National Broadband Gap, the Commission therefore implies that it has reached a decision to use auctions to calculate and distribute CAF

[84] *National Broadband Plan*, p. 13.

support.[85] This decision would increase the amount of USF funding needed but would not ensure that broadband services would be provided to all households.

b. The Gap Estimate Aggregated Gaps at the County Level

The Assessment Module reached its National Broadband Gap estimate in three steps. First, the Assessment Module estimated broadband gaps at the census block level. Second, the Module aggregated those gaps at the county level. Finally, the Module aggregated the county data to arrive at the National Broadband Gap of $23.5 billion. By including the second step, the Commission produced an unrealistic estimate of the broadband gap.

The *NOI* recognized that private sector firms typically "evaluate the profitability of deployment decisions at a larger, more aggregated service-area level than a census block."[86] For this reason, the *NOI* correctly observed that "it does not make sense to evaluate whether to build a network at the census block level."[87] The Nebraska Companies agree that costs should be aggregated at the level at which investors make deployment decisions. It is unlikely that a plausible scenario exists for future broadband investment based upon building a separate broadband network for each individual census block.

Unfortunately, aggregating the gaps by county does not solve the problem. Just as there is no plausible scenario for future broadband deployment by census block, so there also is no basis for using counties for this purpose. Although many counties provide roads for their residents, the Nebraska Companies are not aware of any county government that provides

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[85] The use of auctions for calculating or distributing USF support raises many significant issues, but our comments here are generally limited to pointing out flaws in the model. We do note, however, that it seems highly unlikely that there would be more than one bidder in the very rural areas served by the Nebraska Companies.

[86] *NOI*, para. 41.

[87] *NOI*, para. 41; *Broadband Gap Paper*, p. 36.

broadband services throughout its territory. Instead, private companies typically make broadband deployment decisions. Private companies, however, do not make decisions on a county-by-county basis. Such companies do not hold county franchises, and do not serve or enter markets one full county at a time. The mathematical procedure of aggregating cost at the county level is unrelated to real world situations.

County-wide gap averaging did, however, substantially reduce the final measured size of the National Broadband Gap. By averaging gaps at the county level, the Commission offset negative NPV census blocks with positive NPV census blocks within the same county. That reduced the local gap in counties where the overall net NPV was negative and eliminated the local gap entirely in counties where the net NPV was positive. As a result, the current estimate of $23.5 billion is almost certainly inaccurate because it inaccurately presupposes network deployment economies that do not exist.

3. The Assessment Module Does Not Yet Offer a Suitable Platform for Support Distributions

Economic models can be useful, if properly used, but neither the HCPM nor the National Broadband Plan Model currently provides a sufficiently reliable platform for distributing support. Whether a model is suitable to a task depends on the nature of that task, and its consequences.

The Commission has suggested that it may apply the Model for three purposes. The *Broadband Gap Paper* completed the first, estimating the size of the National Broadband Gap. The second possible purpose is to use the Model's cost outputs (and possibly its revenue outputs) as inputs for a formulaic or algorithmic USF distribution mechanism. Existing USF programs operate in this manner, using costs as an input to a support algorithm. The third purpose would be to use the Model's cost outputs (and possibly revenue outputs) as the basis for setting a reserve price in an auction for broadband provider-of-last-resort ("POLR") services.

A model can be suitable for one of these tasks and unsuitable for the other two. The first task, estimating the National Broadband Gap, produces a single output and is the easiest task of the three. The other two require greater local precision. It is much more difficult to derive a model that reliably estimates costs, revenues and financial gaps for small geographic areas. A random modeling error that has negligible effect on a national statistic could have devastating effect when applied to a formulaic or algorithmic support mechanism. The number of unserved customers, the location of existing facilities, and the extent of a competitor's economic gains cannot be matters of guesswork or prediction. The risk is particularly severe for carriers serving small geographic areas where random errors are less likely to cancel and where important but localized events, such as the extent of cable voice competition, can vary enormously. Estimation techniques and proxies that may suffice for a national estimate can be an unreliable foundation for a specific, predictable and sufficient support mechanism.[88]

In comments above, the Nebraska Companies discussed several problems with the Baseline Module and its Cost-To-Serve Module. It was noted that each Module produced unreliable outputs, as measured in selected Nebraska exchanges. With these problems in mind, even if National Broadband Plan Model were an acceptable platform for measuring the National Broadband Gap, it is not sufficiently accurate and reliable to serve as the basis for a support mechanism for individual companies.

[88] *See* 47 U.S.C. § 254(b)(5), (d).

The problem applies equally to the older HCPM Model. The Nebraska Companies do not detail the failures of that model here, in part because the Commission has already suggested that this older model has serious flaws. To the extent that the Commission's current best effort in cost modeling has reliability problems, the older model is far less likely to be satisfactory.

F. The Commission Should Release More Data Concerning the National Broadband Plan Model

Despite the large amount of information provided in the *Broadband Gap Paper* and in the National Broadband Plan Model Documentation paper, the Nebraska Companies find that these documents do not provide sufficient data to allow a full evaluation and response to many of the questions posed in the *NOI/NPRM*.

While the Commission released data files underlying its maps, even those data were aggregated by county. This makes it difficult to test the National Broadband Plan Model predictions against the Nebraska Companies' own data, which generally are organized by study area. To more precisely evaluate the National Broadband Plan Model against the Nebraska Companies' independently developed information, it would be helpful to have access to the Model's outputs at a smaller geographic scale.

The Nebraska Companies note that the Commission has received *ex parte* requests for additional data from AT&T[89] and Windstream.[90] These *ex parte* filings seek information about the National Broadband Plan Model and its inputs. The Nebraska Companies are interested in the answers to these same requests for information. In addition, Windstream asked for

[89] *Ex parte* notice from Mary L. Henze dated June 16, 2010 in WC Docket No. 10-90.

[90] *Ex parte* notice from Frank Schueneman dated June 16, 2010 in GN Docket No. 09-47.

information specific to its own territory, by census block. The Nebraska Companies would be interested in reviewing similar census block information for their own service areas, as follows:

- From the Baseline Module outputs, the served and unserved population, households, and housing units.
- From the wireline Cost-To-Serve Module outputs:
    - the existing amount of fiber and the number of current DSLAMs; and
    - the amount of new fiber and the number of new DSLAMs.
- From the wireless Cost-To-Serve Module outputs, the number of existing and new towers.
- From the wireline and wireless Cost-To-Serve Module outputs, the same cost information that the Commission has already released at the county level.
- From the Demand and Revenue Module outputs, the same information that the Commission has already released at the county level.

This information may allow commenters to evaluate the reliability and usefulness of the National Broadband Plan Model that is the subject of the *NOI*. Prompt release of this information would allow the Nebraska Companies sufficient time to analyze the data before reply comments are due.

III. OTHER DISTRIBUTION ISSUES AFFECTING THE CONNECT AMERICA FUND

In this Section, the Nebraska Companies address other distribution issues affecting the Connect America Fund ("CAF"). These issues include the capabilities of wireline versus wireless technology to accomplish the National Broadband Plan's goals, targeting of CAF support, one-time versus ongoing support of capital expenditures by the CAF and use of satellite technology to accomplish the National Broadband Plan's goals.

A. Wireline Technology Is the Better Buy over the Long Term

1. Wireless Costs Increase Rapidly As Broadband Speed Increases

The *Vantage Point Study* of four Great Plains exchanges compared the estimated investment needed to support wireless broadband services at a 25:1 oversubscription ratio and a 9:1 oversubscription ratio. The results are presented in the following table. [91]

Vantage Point Study – LTE Wireless Investment and Oversubscription

Exchange	BHOL = 160 Kbps (25:1 Oversubscription) Investment Per Unserved Location	BHOL = 444 Kbps (9:1 Oversubscription) Investment Per Unserved Location	Ratio
Verdigre	$ 6,900	$ 12,800	1.9
Stapleton	$ 6,300	$ 11,100	1.8
Gordon	$ 6,000	$ 12,500	2.1
Imperial	$ 4,500	$ 11,000	2.4

This analysis shows that building a wireless network suitable for all customers' 2015 demand (with a BHOL of 444 kbps and an oversubscription ratio of 9:1) is far more costly than building that same network using the current parameters in the Cost-To-Serve Module of the National Broadband Plan Model.[92] The average ratio is 2.0 to 1 which means a cost of twice as much, on average.

Vantage Point did not estimate the costs for wireless networks providing speeds above the 4/1 Mbps standard. Nevertheless, the above findings are indicative. By showing that costs roughly double when the BHOL design parameter is increased from 160 kbps to 444 kbps, one

[91] *Vantage Point Study,* p. 55, Table 6-1.

[92] Earlier in the comments, the Nebraska Companies demonstrated that using a oversubscription rate of 25:1 does not meet the 4/1 Mbps broadband service standard. See comment pages 14 – 17.

can reasonably infer that further increasing the BHOL of the network to accommodate a higher base speed than 4/1 Mbps, would increase costs in a similar manner.

2. Wireline Technology Is Less Costly In Many Areas than Wireless Technology

The Commission has concluded that "[w]ireline tends to be cheaper in low-density areas . . . ."[93] The *Vantage Point Study* of four Great Plains exchanges suggests that this conclusion is correct. Vantage Point compared the estimated investment needed to support wireline DSL service with wireless broadband services at a 9:1 oversubscription ratio. The results are presented in the following table.[94]

Vantage Point Study – Wireline DSL v. Wireless LTE - Initial Investment

Exchange	**DSL Wireline at 4/1 Mbps**	**LTE Wireless at BHOL = 444 Kbps (9:1 Oversubscription)**	
	Investment Per Unserved Location	**Investment Per Unserved Location**	**Ratio**
Verdigre	$ 9,300	$ 12,800	1.4
Stapleton	$ 7,600	$ 11,100	1.5
Gordon	$ 9,000	$ 12,500	1.4
Imperial	$ 3,000	$ 11,000	3.6

In all four exchanges the cost of a suitably designed wireline system is lower than the costs of a suitably designed wireless system. The mean ratio is 2.0 to 1. In the case of the Imperial Exchange, the wireless system is more than three times as costly as the wireline system. Consider also that Vantage Point's analysis excludes spectrum cost, which, if included in the analysis, would make the results even more unbalanced.

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[93] *Broadband Gap Paper*, p. 10. The *Broadband Gap Paper* also draws similar conclusions about the relative "gap" of wireline and wireless, a topic discussed below.

[94] *Vantage Point Study*, p. 55, Table 6-1.

Vantage Point also noted that wireline and wireless assets have different average lives. Wireless networks are comparatively dependent on electronics, which depreciate quickly, whereas many wireline assets, like cables and poles, have longer lives. Vantage Point produced data analogous to the above chart, but displaying 20-year investment costs. The results are presented in the following table. [95]

Vantage Point Study – Wireline DSL v. Wireless LTE - 20-year Investment			
Exchange	**DSL Wireline at 4/1 Mbps**	**LTE Wireless at BHOL = 444 Kbps (9:1 Oversubscription)**	
	20-year Investment Per Unserved Location	**20-year Investment Per Unserved Location**	**Ratio**
Verdigre	$ 19,500	$ 33,300	1.7
Stapleton	$ 12,000	$ 25,300	2.1
Gordon	$ 13,600	$ 24,900	1.8
Imperial	$ 5,800	$ 26,300	4.5

This life cycle analysis shows the advantage even more clearly for wireline. In these four exchanges, wireless is about 2.5 times more expensive over a 20-year period than is wireline, even though wireless was only 2.0 times more expensive initially. In other words, the wireline advantage increases when considering required capital expenditures. The Nebraska Companies expect that the wireline advantage would even be greater if operational expenditures were to be included, since fixed wireless networks are typically more expensive to maintain.

The *Vantage Point Study* also considered the capabilities of wireless networks when engineered to provide comparable performance to that of a wireline network. Vantage Point studied costs in the Gordon Exchange, which is operated by Great Plains. The study considered the costs of upgrading wireless service to a bandwidth of 3.75 Mbps per customer, with no

[95] *Id.*, p. 56, Table 6-2.

oversubscription.[96] The study considered the additional new investment needed to serve all customers in the area. Vantage Point performed the study two ways: 1) with 2 x 5 MHz of spectrum; and 2) with that same spectrum plus three additional 2 x 5 MHz of spectrum. The results are presented in the following table.[97]

Vantage Point – 3.75 Mbps LTE Wireless Service in Gordon Exchange, Nebraska

Investment (000s)

Spectrum Used	Core Network Electronics	Radio Access Network Electronics	CPE	Total	Additional Locations Served	Investment per Location
2 x 5 MHz	$ 145	$91,110	$605	$91,860	866	$106,000
2 x 20 MHz	$6,470	$28,695	$605	$35,770	866	$ 41,300

The results show a very large investment requirement to support a broadband bit rate that has a capacity slightly below the comparable 4 Mbps rate of wireline DSL. The lower value of investment per additional site, $41,300, requires a large amount of spectrum that may not be available.

Comparing per-location investment to wireline is instructive. The table at the beginning of this section notes wireline DSL investment costs in the range of $3,000 to $9,300 per location served. The wireless costs in the above table are a whole order of magnitude larger.

Vantage Point prepared a contrast between the per-megabit costs of various alternative technologies and speeds. The results are shown in the following table.[98]

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[96] Vantage Point selected 3.75 Mbps for practical reasons that favored the wireless installation. A 5 Mhz channel, using a spectral efficiency of 1.5 bps/Hz is capable of producing 7.5 Mbps. That channel can therefore support two customers using 3.75 Mbps, but only one using 4.00 Mbps.

[97] *Vantage Point Study,* pp. 63-64.

[98] *Id.,* p. 62. Wireless rates are measured by BHOL, not advertised speed.

Vantage Point Study – Wireline v. Wireless Investment per Megabyte			
	Wireline	***Wireless***	
Exchange	***4/1 Mbps No Over-subscription***	***4/1 Mbps 25:1 Over-subscription***	***4/1 Mbps 9:1 Over-subscription***
Verdigre	$ 2,328	$ 13,356	$12,482
Stapleton	$ 1,899	$ 25,904	$ 19,722
Gordon	$ 2,247	$ 29,137	$ 25,375
Imperial	$ 739	$ 23,645	$ 20,293

The table shows that, on an actual throughput basis, wireline technology designed to meet the 4/1 Mbps standard has a strong advantage on a per-megabit basis.

3. Wireline Is Likely to Be Even More Attractive in the Future

The Nebraska Companies assert that the existing advantage of wireline networks will become even more pronounced as subscriber bandwidth demands increase. Fiber-based wireline networks are more cost effective per megabit than wireless networks, and such networks provide superior performance. Landline fiber optic technology already provides speeds of 75 Mbps downstream and 37.5 Mbps upstream, and even higher speeds of up to 10 Gbps are planned.[99] It is reasonable to expect that the comparative advantage of fiber technology will only grow in the future due to improvements in electronics.

Wireline service, provided through fiber optic cables, has much more capability for growth than wireless services. While both technologies have been improving, wireline technology has historically provided maximum throughput rates that are ten times greater than wireless.[100] This ratio is likely to continue or even be exceeded.

[99] *Id.*, p. 23.

[100] Rysavy Research, Mobile Spectrum Demand, p. 21.

Vantage Point estimated the comparative costs of providing higher capacity services in selected Nebraska exchanges. The results are shown in the following table, which also shows the costs of a nearly-comparable wireless network.[101]

Vantage Point Study – Wireline v. Wireless Investment at Higher Speeds (No oversubscription)

		Wireline		Wireless
	Exchange	*20 Mbps*	*100 Mbps*	*3.75 Mbps*
Investment (000s)	**Verdigre**	$ 765	$ 2,080	
	Stapleton	$ 3,785	$ 4,750	
	Gordon	$ 9,840	$ 13,975	$ 35,770
	Imperial	$ 6,735	$ 12,560	
Investment per Unserved Location	**Verdigre**	$ 10,800	$ 5,600	
	Stapleton	$ 12,500	$ 9,400	
	Gordon	$ 10,400	$ 7,100	$41,300
	Imperial	$ 8,000	$ 6,000	

Considered on a raw bandwidth basis, wireline is clearly superior. The table shows it is less costly to provide 100 Mbps wireline service to all unserved areas in Gordon[102] than to provide wireless service at 3.75 Mbps with no oversubscription. Wireline remains advantageous even with the application of an oversubscription ratio, such as 9:1. In that case the table indicates that it is far less costly to provide 100 Mbps wireless service in Gordon than to provide 33.75 Mbps wireless service[103] with a 9:1 oversubscription.

[101] *Vantage Point Study*, p. 65. The definition of unserved location is not the same in all three columns. For 3.75 Mbps wireless the definition of unserved was the same as in the rest of the *Vantage Point Study*, namely whether existing wireline facilities can provide 4/1 Mbps. For the 20 Mbps wireline study, if the wireline facilities could not provide 20Mbps service, customers were considered unserved. Likewise, at 100 Mbps, if the wireline facilities could not provide 100Mbps service, customers were considered unserved. Verdigre currently has 135 FTTP customers who were considered served in all studies.

[102] Vantage Point did not calculate wireless network investment at 3.75 Mbps in the Verdigre, Stapleton or Imperial exchanges because Vantage Point believed the costs would have been even higher than in Gordon.

[103] 3.75 Mbps x 9 = 33.75 Mbps.

In sum, the wireline advantage grows as speed increases. This is in large part because most of a fiber to the home ("FTTH") investment is cable that has a long life and, incremental costs are primarily for less expensive electronics.

Even if wireless service is satisfactory initially for some customers, the growth in broadband demand will eventually overtake its ability to provide adequate service. A new fixed wireless network constructed now would have a higher initial cost than a network designed solely for mobile service, yet it would likely require replacement in five or ten years. Once demand exceeds the capability of 4G wireless, the 4G tower locations may not necessarily be optimal for mobile service, and the towers may have little salvage value. Even when future capital spending is discounted using NPV analysis, a plan that requires the sequential construction of two networks in remote and high cost rural areas seems wasteful.

Simply put, it appears short-sighted to encourage fixed wireless build-outs in rural areas to meet customers' broadband needs. A wireless LTE network is unlikely to fully satisfy present demand, much less to keep pace with demand growth, and is based on unproven technology. The Nebraska Companies believe that building two networks in rural areas is a wasteful use of federal USF funding, and that such a course of action will deter future construction of networks adequate to meet future bandwidth needs. It is also unrealistic to assume that the wireline network will survive if the Commission chooses to fund wireless networks in the near term that are incapable of expansion to meet future growth in demand. At the point the Commission decides that "wireless networks can longer meet the demands of fixed broadband,"[104] the wireline network may have been abandoned therefore requiring significantly

[104] *Broadband Gap Paper*, p. 42.

more time and investment to bring reasonable levels of broadband to rural areas. Chairman Genachowski has proclaimed that all Americans should be able to "enjoy the benefits of 21st century communications networks."[105] Aggressive speed targets and ongoing investment in fiber networks, rather than in wireless platforms with limited bandwidth capabilities, offers a better means to that end in light of the nation's limited universal service resources.

B. Costs Should Be Measured at the Study Area Level and Ultimately Targeted on a Smaller Scale, Such as Non-Competitive Areas

The Commission seeks comment on the geographic area that should be used in calculating the cost of deploying a network and providing services, and the advantages and disadvantages of using a particular geographic area to determine either costs or the gap between costs and revenue.[106] The *NOI* also notes that the National Broadband Plan Model estimates the national gap by assessing costs and revenues at the county level.[107] The *NOI* acknowledged that "geographic granularity is important in capturing the real costs associated with providing broadband service in rural and remote areas."[108] The Nebraska Companies urge that it is necessary to continue to calculate support at a study area level, but also recommend that future broadband support can be targeted to smaller areas.

The first recommendation by the Nebraska Companies is that the Commission should continue to aggregate costs over the supported carrier's entire service area, or "study area." This option reflects the current deployment of networks and the long-term investments made by eligible carriers throughout the study area, and also benefits from economies of scale derived

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[105] Julius Genachowski, speech at NARUC Conference, Washington, DC, Feb. 16, 2010.

[106] *NOI*, paras. 41-42.

[107] *Id.*, para. 41, citing *Broadband Gap Paper*, p. 37.

[108] *NOI*, para. 41.

from serving larger areas. Further, this option would ensure that each high cost area has at least one broadband POLR that will be a financially viable service provider.

The second recommendation by the Nebraska Companies is to eventually calculate support on a targeted basis over a small area, such as a census block or a "Non-Competitive Area" that would be defined by the Commission. This level of aggregation would allow for support distributions to be targeted to areas where there is no business case for a broadband POLR to invest in sufficient broadband facilities to meet the 4/1Mbps standard.

When and if the Commission begins distributing support over smaller areas, the Commission must also ensure that providers meeting existing voice COLR obligations, as well as future broadband POLR obligations, receive sufficient support for continued compliance with the duty to serve. Just as the Commission will properly assign supported carriers a duty to serve defined service areas,[109] the Nebraska Companies believe that the carrier should receive sufficient support to perform that task adequately.

The *NOI* also specifically asks whether costs should be aggregated to the county level. While this option may be administratively attractive, it does not correspond with any relevant facts involving deployment of telecommunications or broadband. Investing carriers do not make incremental investment decisions by county. Existing providers of voice and broadband do not have duties to serve that are congruent with county boundaries.[110] Moreover, no mechanism exists on a county-by-county basis to transfer support from one provider's lower-

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[109] As the Nebraska Companies explain in Section IV.B below, satisfactorily delivering broadband will require the Commission to define a duty to serve for broadband services, to define the service areas where that duty will apply, and to enforce that duty once it has been created.

[110] Attachment C to these comments is a map of the State of Nebraska illustrating county boundaries as compared to the service areas of incumbent local exchange carriers ("ILEC") as have been certificated and approved by the Nebraska Commission.

cost area to support a higher-cost area served by another provider. Finally, county cost averaging (if combined into county service areas) would be likely to create a patchwork of overlaid service areas resulting in numerous areas where there is simply no provider offering voice or broadband services.

C. CAF Recipients Should Be Required to Use Support in High Cost Areas

The *NOI* articulates a Commission goal of distributing universal service funds in a "*targeted* manner that avoids waste and minimizes burdens on American consumers." (emphasis added)[111] The *NOI* also expresses a desire to "ensure that support is *targeted* toward extending broadband service to unserved areas." (emphasis added)[112]

The Nebraska Companies agree that support should be targeted to high cost areas. The task has two essential components. First, the Commission must allocate support differentially to high cost "targeted" areas ("targeted allocations"). Second, the Commission must restrict the way that carriers use support ("targeted uses") so that the support actually benefits services in the high cost or negative NPV gap areas that generated the support allocation.

Targeted allocations and targeted uses work best in tandem. It is impossible to target uses without first identifying the high cost areas where the funds must be used. Likewise, a system with only targeted allocations is likely to be ineffectual because carriers would be free to spend any support received in highly competitive areas where costs are lowest, regardless of how the Commission calculated the amount of that support.

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[111] *NOI*, para. 2.

[112] *Id.*, para. 3; *see also NOI*, para. 4, note 12 (earlier FCC order had articulated a goal to better target support to carriers serving high-cost areas).

The Nebraska Companies recommend that the Commission impose some targeted uses obligations for any CAF one-time grants as well as for CAF ongoing support. Since many carriers now face competition, without such a requirement, recipient carriers would likely use support in areas of greatest competition rather than greatest gap.

D. The Commission Should Adopt a Mechanism That Allows Carriers to Vary Capital Expenditures from Year-To-Year and to Install Fiber to the Home under Some Circumstances

The Commission has used an NPV analysis to bring future investments and expenses back to current dollars. It is useful to reduce all dollar flows to a single NPV when evaluating options for action such as whether to make an investment in extending broadband in a rural area.

Nevertheless, the Nebraska Companies believe the approach used for calculating the NPV of the investment gap cannot and should not be used to determine ongoing support amounts on an *individual company basis*. The Model's approach of calculating the NPV by estimating a project's start date and then assuming levelized costs and revenues over the life of the project is unlikely to match the actual cash flows associated with deploying, maintaining, and operating a broadband network. If CAF support were distributed in the same levelized manner, support would be insufficient to meet the cash flows necessary to operate and maintain the network in some years while providing excessive funding in other years. The Model, therefore, cannot be relied upon to provide predictable and sufficient ongoing support to carriers providing broadband Internet service.

The Commission should also explicitly recognize that carriers have capital expenditure needs every year. Very few networks were constructed in a single event. In most systems, some loops are old and need replacement, a cable at a time, or even a whole exchange at a time. The Commission's existing support mechanisms like High Cost Loop accommodate this annual variation. Support may be used for debt service on capital that is raised privately. Carriers are not required to seek direct public funding for the capital expenditures. A capital expenditure grant can be useful, but if the Commission were to establish rules describing how CAF support will be provided for debt service on approved network capital expenditure upgrades, CAF support would be even more effective at promoting the National Broadband Plan goals.

The Nebraska Companies understand that the Commission has a concern that some companies in the past may have used public funds to build extensive high capacity FTTH networks, at great cost to the public, and without much interest from local consumers. Although FTTH is expensive, the Commission should not presume that all expenditures for FTTH are wasteful. Nevertheless, there are legitimate reasons why a prudent landline company would install FTTH.

One good reason is to replace old distribution facilities. A portion of a distribution route or even an entire exchange may have old cables that are unreliable and that generate high maintenance costs. Installing a replacement copper network makes no sense today in terms of the broadband and other functionality requirements of the telecommunications network. Similarly, cost considerations may push a carrier to install FTTH, as copper is expensive today, often more so than fiber optic cable. Under these circumstances of replacing old plant, FTTH installations can make sense, even if the current subscribers are not yet interested in high capacity broadband.

E. Satellite Systems Cannot Meet Minimum Standards

The Commission evaluated satellite systems as a possible alternative to wireline and terrestrial wireless. However, satellite services are not satisfactory for a primary broadband connection. In addition to the bandwidth constraints associated with shared access networks, satellite has extremely high latency. For this reason, satellite-based broadband systems are unsuitable for a variety of Internet functions, including teleconferencing, remote medical services, and VoIP. The Commission should specifically inquire in future NOIs regarding the capabilities of satellite services to provide high quality, reliable voice communications.

The Nebraska Companies submit that the Commission should not rely on satellite systems as a broadband solution, except in very remote areas where neither wireline nor wireless technologies are feasible at a reasonable cost.[113] Even in these remote areas, the Commission should consider whether it should take other actions to maintain the current network that provides quality voice service. If the Commission does decide that some areas of the country should rely on satellite for broadband, the Commission should consider supporting the continued presence of existing wireline voice services in those areas as well.

IV. BROAD POLICY CONCERNS

The *NOI/NPRM* states a desire to develop a "detailed analytic foundation necessary for the Commission to distribute funds in an efficient, targeted manner that avoids waste and minimizes burdens on American consumers."[114] Procedurally, the National Broadband Plan acknowledges that the Commission should initiate a proceeding to consider questions of jurisdiction, regulatory structure, numbering and carrier of last resort obligations.[115] The Nebraska Companies are pleased to learn that the Commission plans later in 2010 to issue an NPRM addressing "USF Transformation."[116]

Although the USF Transformation proceeding has not yet begun, the *NOI/NPRM* poses many detailed questions regarding models and auctions. However, there are no comparable

[113] *Vantage Point Study*, Section 9.5.

[114] *NOI/NPRM*, para. 2.

[115] *National Broadband Plan*, p. 59, Recommendation 4.5.

[116] FCC Press Release April 8, 2010, referring to a schedule "*Proposed 2010 Key Broadband Action Agenda Items*", available at http://www.broadband.gov/plan/broadband-action-agenda.html.

questions regarding other policy goals and mechanisms that are more fundamental to a successful support mechanism. The Nebraska Companies offer the comments in this section regarding basic policy issues that the Commission should consider and resolve before making decisions concerning less fundamental questions about broadband support mechanisms. The Nebraska Companies hope that the following comments will assist the Commission in framing questions for future NOIs and NPRMs.

A. The Broadband Speed Standard Proposed in the National Broadband Plan Is Inadequate

The National Broadband Plan recommends that the Commission direct public investment toward meeting an initial national broadband availability target of actual 4/1 Mbps.[117] This target was based on the assumption that a household only requires 1 Mbps downstream today[118] and that 4/1 Mbps target would provide some "headroom against rapid obsolescence."[119]

The Nebraska Companies submit that the proposed standard is inadequate to meet the goals of Section 254. Moreover, such standard is unlikely to meet the National Broadband Plan's goal of ensuring that all Americans, including those in rural areas "have access to modern, high-performance broadband and the benefits it enables."[120] The proposed standard is unlikely to meet the National Broadband Plan's mission of creating a "high-performance America – a more productive, creative, efficient America in which affordable broadband is available everywhere and everyone has the means and skills to use valuable broadband applications."[121]

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[117] *National Broadband Plan*, p. 135.

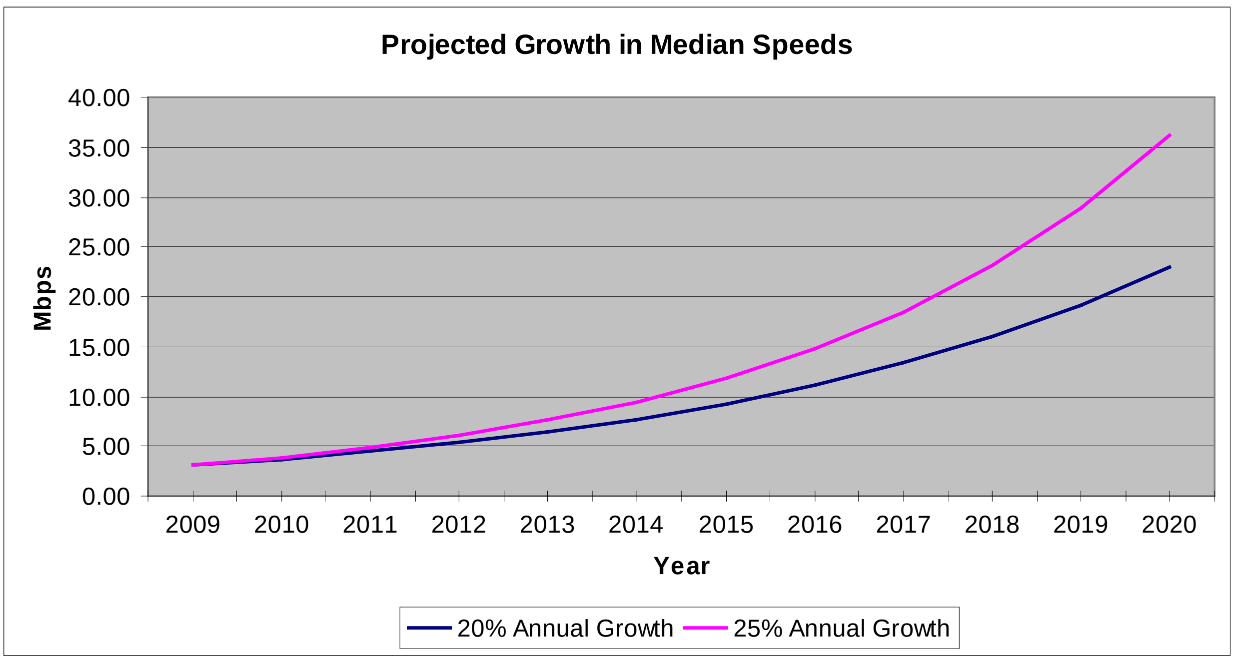
[118] *Broadband Gap Paper*, pp. 42-43.

[119] *Id.*, p. 43.

[120] *National Broadband Plan*, p. 29.

[121] *Id.*, p. 9.

Median actual broadband speeds have been growing exponentially over the past 15 years, and this trend can be expected to continue, or possibly accelerate, over the next decade. If demand increases at a 20% pace, which is the average rate over the past 15 years, then by 2020 the median speed will be 23 Mbps. Similarly, if demand increases by 25%, the 2020 median speed will be 36 Mbps. Thus, the 4/1 Mbps standard will be obsolete before the Commission implements even the first phase of the Broadband Plan. The following table graphically illustrates the foregoing points.



The Commission's assumed growth rates for broadband speed significantly understate likely growth. Nielson's Law" is a proposition stating that network connection speeds for high-end home users would increase 50% per year, or double every 21 months. Nielson's Law proved largely correct over the decade ending in 2007, and speeds in the United States are expected to continue to rise at annual rates of 50% or greater.[122] Assuming growth according to Nielson's law, the 4/1 Mbps proposed standard already is below median speeds in mid-2010.

As an independent measurement of available broadband speeds, Ookla[123] provides an online speed test through the following site: www.speedtest.net. A related link, www.netindex.com, compiles rolling average download and upload speeds (in Mbps) for the preceding 30 days where the mean distance between the client and server is less than 300 miles. For the period beginning December 20, 2009 and ending June 20, 2010, netindex.com reported average speeds as shown in the table.

	Download	**Upload**
World	7.56 Mbps	2.07 Mbps
United States	9.96 Mbps	2.17 Mbps
Nebraska	8.46 Mbps	1.70 Mbps

The Commission's own data show that many urban customers have service in excess of 10 Mbps – 116 million of the nation's 130 million households can already purchase broadband service at 10 Mbps or better.[124] Comcast, the largest cable television company in the United States with 23.5 million television customers and nearly 16 million broadband customers is currently deploying a 100 Mbps service nationwide.[125]

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[122] Andrew Marshall, *White Paper: Future Bandwidth Requirements for Subscriber and Visitor Based Networks*, Campus Technologies Inc., December 2007, p. 4, 9, available at http://www.campustechnologies.net/pdfs/Future_Bandwidth_requirements_white_paper_CTI.pdf .

[123] Ookla is a provider of broadband speed testing and web-based network diagnostic applications.

[124] *Broadband Gap Paper* at 17, Exhibit 2-A.

[125] *Vantage Point Study*, p. 6.

Given explosive recent increases in broadband speeds, especially in urban areas, a universal target of 4/1 Mbps is likely to be outmoded by the end of this year, even by the Commission's own conservative speed estimates. If the preceding information is correct, the proposed standard for actual network speed of 4/1 Mbps is already significantly lower than the average current speeds in the world, in the United States, and in Nebraska. Moreover, even if it is not already an obsolete standard, it soon will be. Many experts assert that customers will want 100 Mbps broadband access within the next five years and 1 Gbps within the next ten to fifteen years.[126]

These speed differences have important functional consequences. Many of the broadband applications most suited to rural areas do not function well with a connection speed of less than 5 Mbps, and speeds exceeding 10 Mbps are preferred.[127] These applications include diagnostic telemedicine, high-quality distance learning and telecommuting.

The urban/rural difference is another important dimension to this issue. The Commission has also proposed that at least 100 million U.S. homes should have affordable access to actual download speeds of at least 100 Mbps and actual upload speeds of at least 50 Mbps.[128] The contrast between this urban target and the 4/1 Mbps general target is striking. The general target would leave rural residents far behind their urban counterparts who would benefit from

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[126] *Vantage Point Study*, p. 11.

[127] The Broadband Task Force PowerPoint from the September 29, 2009 Commission Meeting; Vantage Point, *Providing World-Class Broadband: The Future of Wireless and Wireline Broadband Technologies*, p. 13. *Vantage Point Study*, p. 10.

[128] *National Broadband Plan*, p. 9.

broadband speeds 25 times faster than rural speeds. Such a large difference would violate the statutory goal that services in urban and rural areas be reasonably comparable.[129]

The standard that the Commission sets now will have long-term effects. The National Broadband Plan sets a target of achieving the 4/1 Mbps standard in 2020.[130] Long-life broadband assets have a twenty year life span.[131] Therefore, today's speed standard will likely affect the service of some broadband customers thirty years in the future. A too-modest standard, based on speeds that already have or will soon be surpassed by the average customer, will generate investment in durable equipment that will be unsuitable over most of its useful life for use in a technologically advanced country.

Even if the Commission reevaluates the universal target every four years, rural customers will continually be in "catch-up" mode. The risk is far greater if advancing broadband speed expectations require technology change. The time required to implement such a technology change will mean that rural customers will have subpar service for years to come–not to mention that precious limited federal resources may be wasted on technology that fails to meet customer needs. When assigning universal speed targets, the Commission should account for the time required to build a network and the speeds expected to be commonly available nationwide during the period in which the network will be operational.

A 4/1 Mbps speed target will also disadvantage the U.S. in global competition. The National Broadband Plan asserts that 4/1 Mbps is aggressive when compared with other nations'

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[129] 47 U.S.C. § 254(c)(3).

[130] *National Broadband Plan*, p. 135, Exhibit 8-A.

[131] *Broadband Gap Paper*, p. 34.

universal availability targets.[132] In fact, the target is quite conservative when timing differences are considered. For example, according to the National Broadband Plan, South Korea's 1 Mbps standard for downloads applied in 2008.[133] Assuming an annual growth rate of 25% for 12 years, a 2020 target for South Korea would be 14.5 Mbps. Similarly, Ireland's 1 Mbps standard applies this year, 2010. Adding ten year's growth at 25% produces a 2020 target for Ireland at 9.3 Mbps. Similar results apply for Germany, the UK, and Finland. Finland, a country with approximately half the population density of the U.S., has established a requirement of universal broadband availability of 1 Mbps for the year 2010 and plans to extend 100 Mbps connections to over 99% of its population by 2015.[134] If the United States wishes to be a leader in broadband deployment, the Commission should set a more ambitious universal speed target.

The Nebraska Companies suggest that given the above growth rates and consumer demands, the Commission should select a goal that will meet the needs of customers for at least the next decade. If the Commission wants the United States to lead the world, a rural goal of 20 Mbps for download speed and 5 Mbps for upload speed would be more appropriate. This standard more closely matches broadband capabilities that are already available in most urban areas. In addition, a speed of least 20 Mbps downstream is required to support applications such as telemedicine and telecommuting. Many, if not most, of the locations in the United States can enjoy these types of speeds today, and 20/5 Mbps is more likely to be reasonably comparable to

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[132] *National Broadband Plan*, p. 135.

[133] *Id.*, p. 135, Exhibit 8-A.

[134] Effective July 1, 2010, Finland has declared that every Finn shall have access to a 1 Mbps broadband connection, and "has vowed to connect everyone to a 100 Mbps connection by 2015." BBC News On-line News Service, July 1, 2010.

urban speeds and would address the United States' poor performance in recent international comparisons.

If the Commission were to adopt a standard of 20/5 Mbps, this standard should be applied only prospectively, and should not be a minimum requirement for 2015. Specifically, 20/5 Mbps should be the minimum design standard for any new construction supported with CAF monies. This standard will reduce the risk that CAF funds will be used for facilities that soon become insufficient.

However, 20/5 Mbps should not be a minimum qualification for legacy USF support. Over a period of years, existing networks can evolve to provide 20/5 Mbps service. No carrier that provides voice or broadband and that receives support today should have that support reduced or terminated within the foreseeable future because its broadband service does not currently meet the 20/5 Mbps standard. If the Commission does choose to establish a minimum broadband speed standard for legacy support eligibility, it should increase that speed gradually over time. The Commission should review each proposed increase before it takes effect to ensure that the increased speed requirement reflects measured consumer usage changes and takes appropriate account of carriers' expectations to engage in reasonable long-term capex planning and to gradually replace old but serviceable facilities that are approaching the end of their useful life.

B. The Commission Should Preserve and Continue to Utilize the Benefits of the Existing Network that Provides Broadband Service in Many Locations

The Nebraska Companies endorse the Commission's desire to support broadband networks. However, the Commission should also recognize the important public benefits that Federal USF programs have already produced for the existing national telecommunications network. Under current policy, that network has been evolving to a broadband-capable network that provides quality broadband services in many "served" areas. The Commission should make a public commitment to preserve and advance those benefits. The existing national telecommunications network is engineered to provide end-to-end quality of service ("QoS") as well as service availability. The existing network is designed around the core concepts of full redundancy, survivable fiber rings, as well as 99.999% reliable hardware.

1. The Commission Should Promote Reliability and Service Quality in Funded Broadband Networks

The Commission anticipates supporting only broadband availability through the CAF after 2020.[135] For that reason, the Commission should assume that in many rural areas the sole means to provide voice service after 2020 will be as an adjunct to broadband. Voice transmission, therefore, establishes a floor for broadband network service quality. The Commission should articulate the goal that, after 2020, VoIP services riding on USF-supported broadband networks will provide a customer experience for voice communications with quality and reliability that is substantially equivalent to the service provided by today's wireline voice network. Upcoming NOIs and NPRMs should inquire specifically concerning the technical standards needed to implement this goal as well as how those standards should be enforced.

At minimum, the new standards should address network operating requirements under normal baseline conditions. These standards should be sufficient to support packet-based VoIP services with consistently high voice quality, including standards for connection speed, packet

[135] *National Broadband Plan*, p. 136 (elimination of legacy High-Cost program from 2017 to 2020).

loss, jitter and latency. These standards should also include voice quality factors, such as the "R-factor"[136] or "Mean Opinion Score."[137]

Providers should also clearly inform customers about the actual available bandwidth of the communications offered. Median speeds on broadband networks are generally less than advertised speeds.[138] The Commission itself noted that median speeds and advertised speeds are sometimes quite different.[139] In today's environment, provider contracts often contain fine print that says, in essence, that speeds are only guaranteed by the provider's best efforts. Defining a meaningful speed standard that is instructive to customers may be a difficult task for the Commission.

Supported networks should also be capable of handling peak demand and anticipating rapidly changing user traffic patterns. Facilities that are common to multiple users should be capable of handling all foreseeable user loads.[140] A future NOI should inquire as to whether the Commission should establish engineering standards, such as allowable loading of common facilities, or performance-based standards.

Due to the dynamic nature of Internet traffic, the Commission should require service providers that wish to receive federal USF support for broadband to test and certify for proper

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[136] "R-factor" is a calculation of voice quality described in the ITU's "E-Model" (ITU-T G.107) that takes account of quality of service statistics as well as other voice impairment factors. The Commission might prescribe that 90 percent of voice calls placed on USF supported broadband networks must maintain an R-Factor of 80 to 94.

[137] The Nebraska Companies suggest, for example, that the Commission might prescribe that 90 percent of voice calls placed on USF supported broadband networks must maintain an MOS of 4.0 or more.

[138] *National Broadband Plan*, pp. 21-22.

[139] *Id.*, p. 25, note 48

[140] As was noted above, the *Broadband Gap Paper* methodology is flawed in that it contrasted the costs of a wireline network that is capable of providing 4/1 Mbps service to all its customers concurrently with a wireless network that was heavily oversubscribed and that constrained heavy users.

QoS operation, buffering, queuing and policing of network traffic. The service provider should be required to monitor jitter, delay and packet loss. Automatic alarms should notify centralized network managers when quality drops below specific thresholds. QoS should be required end-to-end, from handset-to-handset across the provider's network, including via the "air interface" of a wireless access medium.

The broadband network should also be capable of handling emergency communications reliably and without service interruption. The Commission should inquire in future NOIs whether achieving this goal on IP networks requires installation of QoS software or hardware that can prioritize emergency packets and ensure that emergency service availability is not interrupted. A future NOI should also inquire as to what performance standards should apply to emergency communications.

Broadband voice services push more intelligence to the edge of the network and increase the complexity of provision, operating, and troubleshooting customer premise equipment. As users increasingly utilize complex customer premise equipment, users will require proper instruction or education to efficiently understand the new technology. A future NOI should inquire as to whether supported broadband and VoIP providers should be required to offer and maintain online training or user guides.

Of course, the reliability of the wireline communications network is a significant public benefit. The Commission should announce a specific intention to preserve and advance this benefit and should establish standards for network reliability as an underlying principle for its broadband USF program. Such standards should be comparable to the regulatory requirements and historical record pertaining to the public wireline voice network.

A future NOI should also inquire whether supported broadband networks should be required to meet standards for electric supply backup. These standards should include both central office equipment electric supply backup and customer premise equipment electric supply backup. Network elements within the voice network responsible for routing calls, E911 and for providing dial-tone should be equipped with processor, line-card, and power redundancy. Any USF-supported service provider should also be required to maintain a full set of spares in all locations in which it operates in the event of a hardware failure.

VoIP technologies share common media and transmission paths as Internet data and IP-based multimedia services. The sharing of these paths can open a number of potential security vulnerabilities for the subscriber, including intercepted active calls, redirected calls, and captured and decoded dialed digits (dialed for such purposes as credit card transactions). The Commission should require supported service providers to deploy VoIP signaling-aware firewalls to protect the voice network from IP-based vulnerabilities. The Commission should also require service providers to deploy methods of limiting VoIP signaling and traffic so that providers can block malicious attacks that might otherwise cause service loss.

The wireline network is reliable in large part because it uses high quality transmission facilities and is less sensitive to variable environmental conditions. These features promote both reliability and consistently high voice quality. Wireless services do not generally match wireline standards of reliability or quality. A notable example is microwave backhaul which is often affected by weather.

To illustrate, the Consolidated Companies in Nebraska are interconnected with a regional mobile wireless carrier that serves mobile subscribers within Consolidated's service area. The carrier is interconnected to Consolidated's switch and uses wireless backhaul for middle-mile transport.[141] Consolidated is therefore able to log that carrier's backhaul downtime. Consolidated's records show that the microwave link has been down more than once per week, on average. Usually the drops last for 15 to 20 seconds, which is long enough to terminate a switched call. Some drops approach an hour. In addition, wireless distribution networks have "holes" in signal coverage, even in areas that purport to be within the service radius of a nearby cell tower. The State of Nebraska has recognized the greater reliability of wireline networks by requiring the use of wireline facilities to transport emergency 911 calls and information. Even 911 calls that originate on wireless phones in Nebraska are routed and processed through wireline networks.

Finally, wireline facilities serve fixed locations and generally have more stable usage patterns. Some wireless technologies also serve fixed locations only. LTE wireless, however, supports both fixed and mobile services. For a mobile service, the unplanned arrivals of many mobile phones within range of a single tower can disrupt service and cause loss of broadband throughput speed and dropping of voice calls.

In sum, these same physical and network features matter for IP networks as much as for voice networks. Wireline services, especially those using fiber optic transmission, are more reliable than wireless or satellite-based services.

As a condition for carriers receiving broadband USF, the Commission should establish and administer facilities-based service quality indices, either directly or by delegation to state

[141] This carrier uses five gigabit licensed spectrum with towers at approximately 30-mile intervals, which is line-of-sight in much of Nebraska.

commissions.[142] Those standards should ensure that customers receive prompt and effective service when seeking new connections and reporting trouble.

The Commission should enforce its standards in three ways. First, service providers who receive operating support should be required to certify compliance with the standards. Similarly, service providers who receive advance construction grants should submit a certificate from a professional engineer certifying that the planned installation will meet the Commission's engineering standards. This recommendation is consistent with the National Broadband Plan, which states that in the future, grants of broadband funding will be conditioned on grantees serving as broadband POLRs.[143]

Second, providers that receive support should be required to monitor and report compliance with performance standards. Periodic measurement and reporting should be required for several years after receiving any construction support and during a specified period for operational support. This ongoing monitoring is necessary to ensure that service commitments by service providers are fulfilled. Reporting should cover the frequency that median delivered broadband speeds do not match the Commission's own minimum speed standard. The scope of monitoring should include sufficient network quality variables that affect the quality of VoIP services, such as throughput, dropped packets, corrupted packets, latency, and packet jitter.

Third, standards should be enforceable through financial penalties that apply for several years after a construction grant has been received. The Commission should specifically consider establishing a point-based penalty system similar to those used in some states for alternative regulation plans or for carrier-to-carrier local interconnection quality assurance plans. These

[142] Federalism issues and carrier-of-last-resort issues are discussed in more detail in Section IV.C below.

[143] *National Broadband Plan*, pp. 145, 149 and 151.

plans calculate penalties as a mathematical function of periodically calculated compliance metrics.

2. The Commission Should Promote Continued High Voice Service Penetration Rates

The voice network has achieved a high national subscriber penetration rate. In the Commission's recent order issued in response to the *Tenth Circuit Remand Order*,[144] the Commission reported that the telephone subscribership penetration rate in the United States in 2009 had increased to 95.7%. This penetration rate is the highest reported penetration rate reported since the Census Bureau began collecting such data in November 1983.[145] The Monitoring Report also shows that the penetration rate in Nebraska was 99% in 2008.[146] Only three states exceeded that rate, and only slightly. The Commission should establish an explicit goal that the current wireline voice penetration rate will not decline in any area during the nation's transition to broadband networks.

There are many ways in which subscriber voice service penetration might decline as the nation shifts to broadband networks. For example, a customer who has been accustomed to receiving voice service at rates of perhaps $20 or $30 per month might drop service if the only way to buy voice service in the future is in a broadband bundle that costs $50 to $70, or more. Or, an ILEC might experience a business failure due to loss of funding, leaving customers with only broadband-based options or no options for replacement voice service.

[144] *High-Cost Universal Service Support*, WC Docket No. 05-337, Order on Remand and Memorandum Opinion and Order, FCC 10-56, (released Apr. 16, 2010).

[145] *Id.*, para. 18, referring to Industry Analysis and Technology Division, Wireline Competition Bureau, *Telephone Subscribership in the United States*, p. 23.

[146] Universal Service Monitoring Report, 2009, Table 6.4.

Increasing or at least maintaining current broadband penetration is an important goal. The Commission has already expressed a desire to "maximize the number of households that are served by broadband meeting the National Broadband Availability Target."[147] The Commission should also affirm an additional goal that voice subscribership penetration will not decline in any area as the nation shifts funding to broadband networks.

In sum, the Commission should announce a general policy that there should be no loss of voice service penetration or broadband penetration as a result of the upcoming transition. To achieve this goal, the Commission should evaluate proposed changes to universal service, in part based on how the change is likely to affect penetration rates for voice and broadband services. Future NOIs and NPRMs should seek detailed comment on whether proposed policy changes will affect these penetration rates.

3. The Commission Should Evaluate the Effects of Policy Changes on Existing Voice and Broadband Networks

The Nebraska Companies understand that the Commission cannot guarantee that any carrier will continue in business indefinitely, regardless of what the carrier may do or refrain from doing to preserve its own business. Nevertheless, the Commission's current approach to promoting broadband, combined with its apparently strong interest in cost models and auctions, could lead the Commission to adopt policies that inadvertently reduce voice service penetration.

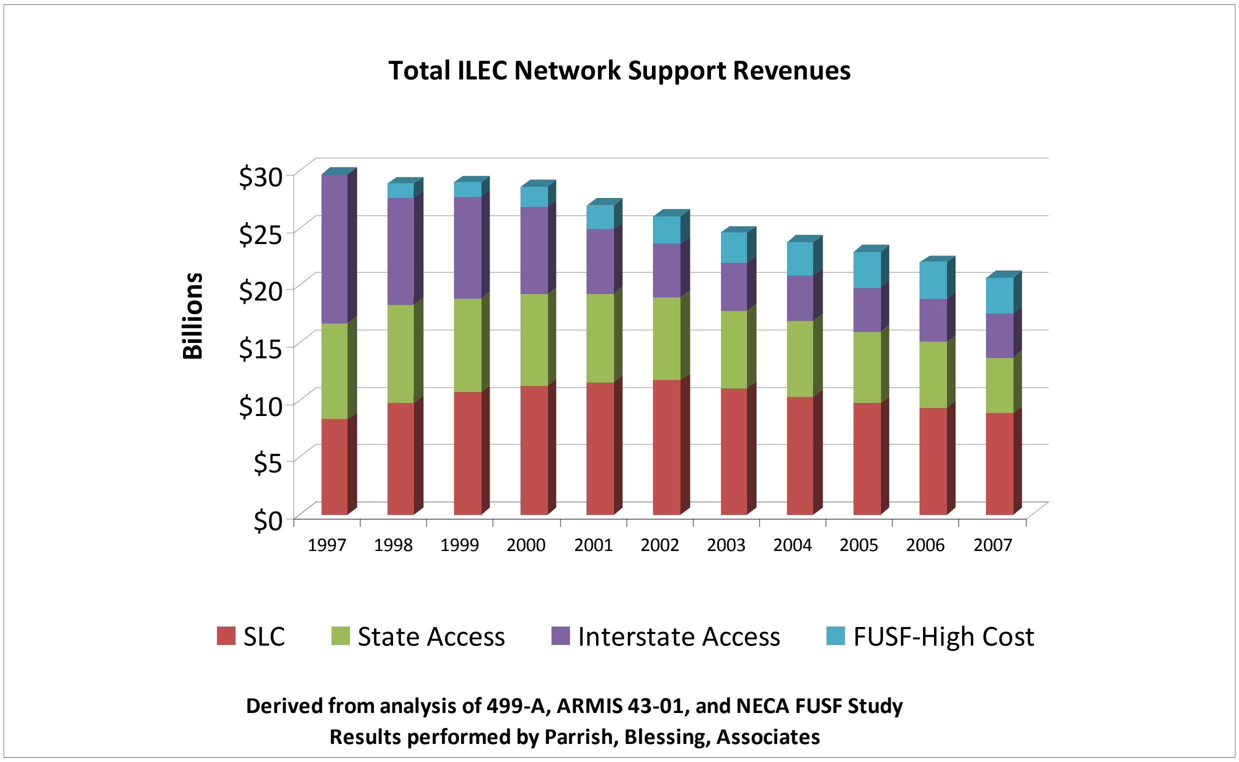
The most dramatic scenario is outright ILEC business failure. If eroding subscribership and revenues lead an ILEC to seek exit from a local exchange market, it is unlikely that a replacement carrier would voluntarily assume responsibility for that entire service territory. Any such business failure is therefore likely to generate subscribership losses in both voice and

[147] *National Broadband Plan*, p. 143; *NOI*, para. 46.

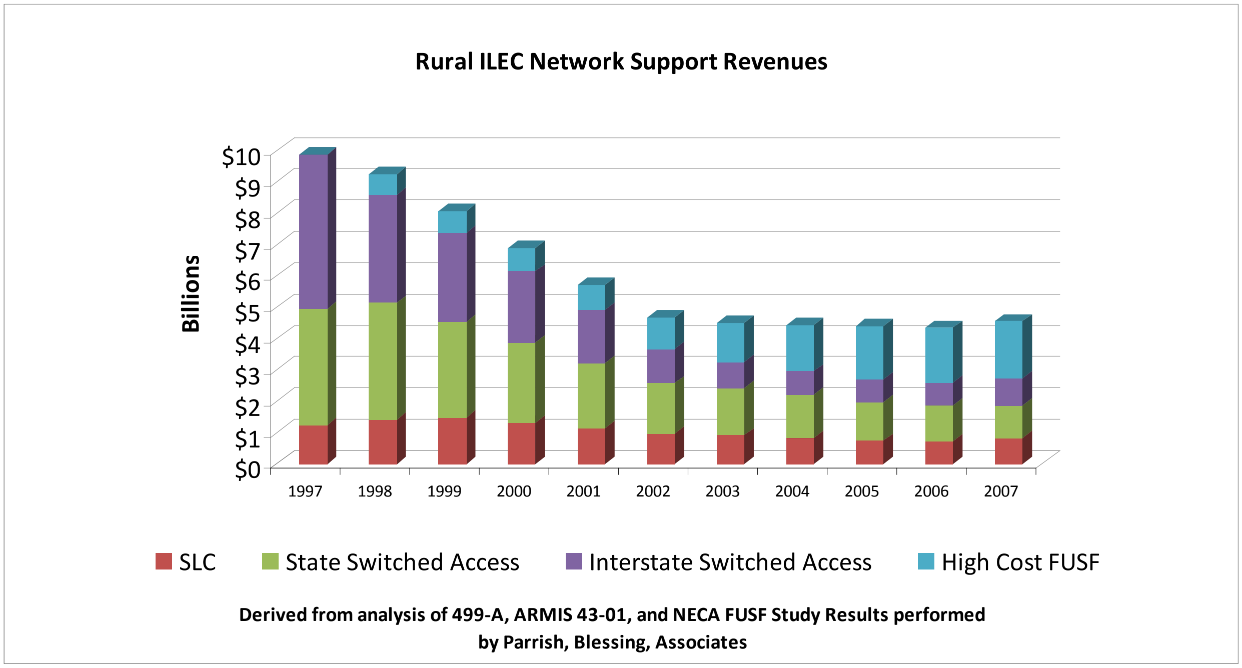
broadband services. A business failure would also generally lead to loss of carrier-to-carrier services that could be critical for the operation of telecommunications generally, especially emergency telecommunications.

A second and less obvious problem scenario involves a lowered rate of private investment. Local exchange carriers currently invest hundreds of millions of dollars each year in voice and broadband services in this country. A significant portion of this investment has been incurred to extend broadband services to previously unserved areas. Any Commission action that has the effect of reducing that current rate of investment could easily slow the rate of broadband adoption. If the rate of private investment slows enough, it could offset the Commission's financial initiatives, causing a net reduction in the rate of broadband expansion.

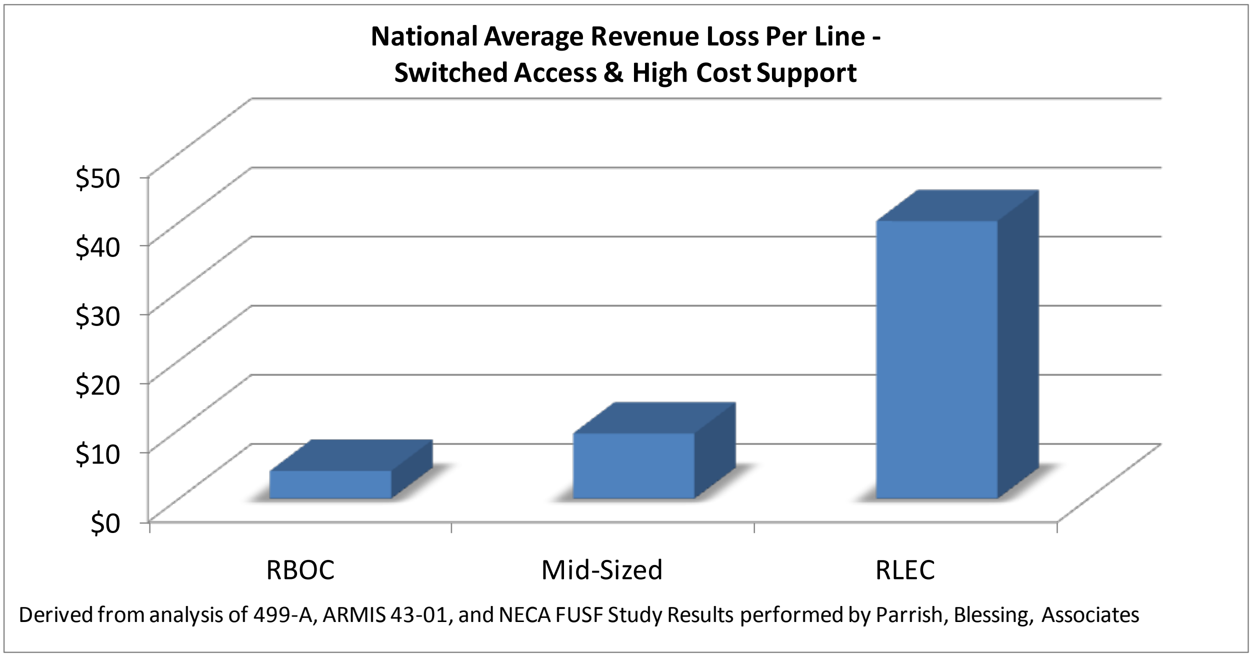
These two scenarios, failure and reduced investment, are no longer unlikely horror stories. Such scenarios may become a reality in some areas in the near future, with further loss of network revenues accelerating the past long-term trend. As shown in the following chart, incumbent LECs have experienced a dramatic decline in network support during the last 10 years.



Among rural ILECs, the percentage decline over the same period has been far larger, as is shown in the following chart.



The Commission has proposed that switched access rates will be reduced and that high cost support will eventually be transferred to a new program.[148] Such a step would especially impact rural LECs, whose per customer network costs are much greater than other carriers. The following chart illustrates how the loss of switched access revenues would affect ILECs, by carrier size. The chart shows that small rural carriers would be severely affected by a loss in switched access and federal high cost support.



[148] *National Broadband Plan*, p. 151 ("While the FCC will initially target CAF funding toward unserved areas, the objective over time is to develop a mechanism that supports the provision of affordable broadband and voice in all areas, both served and unserved, where governmental funding is necessary. The amount of support ultimately required for those areas that currently are served through the receipt of universal service subsidies will depend on many factors, including the evolution of market demand, the precise distribution mechanism selected, and the achievement of efficiencies in an IP-based network."). The Nebraska Companies understand that the Commission intends to keep current HCL, LSS, and capped ICLS support in place for seven years; however it is uncertain what level of CAF funding will be available after that seven year period. This seven-year transition period may not, however, be adequate for incumbents to recover the investments made in embedded plant facilities.

The Commission cannot expect carriers to continue to invest in networks experiencing this level of revenue decline. Under this scenario not only will carriers not invest, but further, a number of carriers may be unable to stay in business, leaving customers unserved.

To avoid this disinvestment and the potential business failures, the Nebraska Companies recommend that the Commission explicitly declare that all proposed policy changes affecting universal service will be evaluated, in part, based on likely effects on existing or incumbent service providers, including voice and broadband providers. This policy would derive not from a concern for those providers *per se*, but to avoid the disruptions and harm to subscriber penetration rates that could follow business failures or investment curtailment by incumbents. The Commission's upcoming NOIs and NPRMs should make detailed inquiries as to how proposed changes to support mechanisms will affect investment by voice carriers, likely failure rates by voice carriers, the impact on the ability to meet debt service payments and the same factors for existing broadband service providers.

Other federal agencies that deal with networks evaluate their policies based on the likely impact on existing investments. For example, federal highway law addresses federal support for the surface transportation network. Just as the communications network uses multiple modes for signal transmission, the surface transportation network offers multiple modes of travel and shipment.

When planning for future highway construction, the U.S. Department of Transportation gives consideration to existing investment, as reported by state highway planners. To receive federal support for construction projects, each state must develop a statewide transportation plan.[149] Each state's plan must consider the transportation network as a whole[150] and must "enhance the integration and connectivity" of the transportation system.[151] Of particular note, the statute requires that state plans must "emphasize the preservation of the existing transportation system."[152] Just as the Department of Transportation takes an overall view of the highway network when selecting projects to fund, the Commission should take an overall view of the telecommunications network when it determines changes to federal USF.

C. The Commission Should Design a Broadband Provider-Of-Last-Resort Mechanism before Making Any Funding Decisions

The National Broadband Plan and the *Broadband Gap Paper* each address carrier-of-last-resort ("COLR") obligations. The *Broadband Gap Paper* noted that COLR policies have been one reason that telephone networks are ubiquitous in rural areas.[153] The National Broadband Plan also states that in the future, grants of broadband funding will be conditioned on grantees serving as broadband POLRs.[154] The National Broadband Plan therefore implies that voice COLR obligations will be transformed in some manner to apply to broadband, and the resulting broadband POLR policy will be enforced, at the least, as a condition for eligibility for universal service support. The National Broadband Plan anticipates a transition docket that will examine COLR obligations, among other issues[155] and recognizes that federal support may need to

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[149] 23 U.S.C. § 135(a)(1).

[150] State plans must provide for "the development and integrated management and operation of transportation systems and facilities . . . ." 23 U.S.C. § 135(a)(2).

[151] 23 U.S.C. § 135(d)(1)(F).

[152] 23 U.S.C. § 135(d)(1)(H).

[153] *Broadband Gap Paper*, p. 84.

[154] *National Broadband Plan*, pp. 145, 149 and 151.

[155] *Id.*, p. 59.

include funding for existing carriers when such carriers have traditional voice COLR obligations and other carriers are selected for broadband support.[156] These preliminary statements are reassuring, indicating that the Commission is broadly aware of the importance of state COLR policies, that complex issues lie ahead in adapting those policies to broadband, and that there will be transition issues.

At the same time, the National Broadband Plan also leaves the impression that the Commission may consider these COLR issues to be comparatively minor implementation matters. In actuality, the design and implementation of a broadband POLR system is a topic of utmost importance to the design of any future broadband support system. Without a well-designed broadband POLR system, it is difficult to ensure that federal funding actually advances universal service goals. Moreover, the Nebraska Companies suggest that it would be premature for the Commission to decide questions regarding modeling or auctions without first deciding how broadband POLR duties will be defined, assigned, and enforced.

1. The Commission Should Account for State COLR Policies

Since COLR duties evolved primarily under state law, the Commission's first task should be to gain an understanding of the scope and diversity of existing state COLR duties. A future NOI should seek comment on these state law arrangements, as well as the resources and skills typically involved in enforcing such duties. This section outlines these duties in an effort to assist the Commission in formulating detailed questions in a future NOI.

In the National Broadband Plan, the Commission defined a carrier of last resort as:

[156] *Id.*, p.137.

> [T]he carrier that commits (or is required by law) to provide service to any customer in a service area that requests it, even if serving that customer would not be economically viable at prevailing rates.[157]

The Commission's definition overlooks some important dimensions of COLR obligations.[158] States impose these duties using a variety of methods. In some states, rules or statutes define COLR obligations, usually by stating duties of incumbent LECs. Duties may also be assigned by case decisions as well as by "certificates of public convenience and necessity" or a similarly named charter or franchise document.

Incumbent LECs have extended lines to a very high proportion of the locations of existing residences and businesses. The voice duty to serve therefore currently protects the great majority of the population. *Without a geographic area to which it applies, however, a "duty to serve" is meaningless.* State commissions traditionally assign "franchise" or "service" areas for this purpose and set exchange or "wire center" boundaries.[159] State commissions occasionally resolve exchange boundary disputes. These cases often require detailed consideration of local historical facts, and sometimes are decided after site visits. Federal law offers state commissions an analogous authority over the designation of Eligible Telecommunications Carrier ("ETC") service areas.[160] A state may also require a COLR to extend its lines into an unserved

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[157] *Id.*, p. 351. Similarly, in the *Broadband Gap Paper*, the Commission reported that "local carriers have had the obligation to serve all households in their geographic area." *Broadband Gap Paper*, p. 84.

[158] *See generally*, P. Bluhm and P. Bernt, *Carriers of Last Resort: Updating a Traditional Doctrine*, National Regulatory Research Institute, Report 09-10, July, 2009.

[159] *See e.g., Neb. Rev. Stat.* § 86-130 (Reissue 2008). This Nebraska statute requires each telecommunications company in Nebraska to file maps of the territory in which it offers local exchange service.

[160] 47 U.S.C. §§ 214(e)(2), 214(e)(5).

community. Federal law echoes this duty of "common carriers," a duty that may be imposed by the Commission[161] or by a state commission.[162]

A second important COLR duty is continuation of service until exit permission is granted by the state commission.[163] Even in the states that require market exit approval, the requirements for obtaining such approval vary greatly by type of carrier. Many states routinely grant petitions for exit by resellers and other carriers with no facilities.

Exit by an ILEC presents the most difficult case. State laws may not provide guidance to manage an exit that leaves customers stranded without a carrier. For example, state mass migration rules typically require a COLR to accept customers, and to build facilities to those customers, when a competitive local exchange carrier fails.[164] The underlying premise is that there will always be a COLR that *can* accept the customers. Federal law (which overlays COLR duties with ETC provisions) simply evades the same question by explicitly addressing only the case wherein a second or subsequent ETC seeks to exit, leaving behind one or more ETCs that still can provide service. [165] To the extent that any state does have workable procedures for exit by an ILEC, the Commission's future NOIs should seek information to facilitate a full understanding of such procedures.

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[161] 47 U.S.C. § 214(d).

[162] 47 U.S.C. § 214(e)(3).

[163] *See e.g., Neb. Rev. Stat.* § 86-134 (Reissue 2008).

[164] For example, the California Public Utilities Commission said that it anticipates appointing ILEC-COLRs to serve as default carriers if no other carrier volunteers, but only if the COLR has sufficient facilities. California PUC, *Order Instituting Rulemaking to Establish Rules Governing the Transfer of Customers from Competitive Local Carriers Exiting the Local Telecommunications Market*, Decision 06-10-021, Rulemaking 03-06-020 at 12-16 (dated Oct. 5, 2006) (*California Mass Migration Order*); *see also,* Mo. Code Regs. Ann. tit. 4 § 240-32.120(3)-(4) (requires ILECs to accept the customers of a failing reseller for at least 30 days).

[165] *See* 47 U.S.C. § 214(e)(4) (state commission must require remaining eligible telecommunications carrier or carriers to ensure that all customers served by [exiting] carrier will continue to be served).

Retail service quality standards are another dimension to COLR duties. These standards typically cover installation intervals, operator-handled calls, dial tone availability, call blocking rates, unscheduled outage times, customer trouble occurrence rates, average response time for trouble calls, reporting of network downtime, and emergency service continuity plans.[166] States may also require COLRs to install backup generators and batteries to maintain service during power failures.[167]

COLRs often must comply with consumer protection standards. These can include requirements that the COLR make certain pre-purchase disclosures to prospective customers, make certain disclosures in advertising, offer trial periods for new customers, provide clear bills, and provide specified cancellation terms.[168]

Carriers-of-last-resort may also be required to provide economic benefits to retail customers, such as low monthly rates to residential customers. COLRs may also be required to provide explicit benefits to specific customer classes, such as low-income customers[169] or disabled customers.[170]

Finally, COLRs have important carrier-to-carrier duties. Today the ILEC network often serves as a linchpin for the functionality of a variety of other networks and that provides services

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[166] *E.g.*, Tex Admin. Code tit. 16, part 2, § 26.54. See generally, Perez-Chavolla, Survey of State Retail Telephone Quality of Service Regulations for Selected Categories of Service: Metrics, Penalties and Reports, NRRI, 2004, available at http://nrri.org/pubs/telecommunications/04-09.pdf.

[167] *E.g.*, Alaska Admin. Code tit. 3 § 53.410(a)(12)(A); Iowa Admin Code tit. 199 § 39.2(3)(h).

[168] *E.g.*, Iowa Admin Code tit. 199 § 39.2(3)(f).

[169] Florida requires a COLR to absorb a revenue loss of $3.50 out of a total local exchange rate discount of $13.50 for low-income customers who participate in the Lifeline program. Fl. Stat. § 364.10(2)(a) (applies to "eligible telecommunications carriers" as defined under federal law and may include wireless carriers).

[170] Vermont requires wireline telecommunications carriers to provide a 40% discount on intrastate services to customers who use adaptive telephone equipment for the deaf, speech impaired or hearing impaired. Vermont also requires carriers to provide free directory assistance to customers who are blind or visually impaired. VT PSB Rules § 7.609(A), (B). These obligations apply to all wireline carriers, but not wireless carriers. *Id.* § 7.602.

that are upstream components for other carriers' retail services. These carrier-to-carrier duties have expanded with every decade of regulation, including equal access in the 1980s and expanded interconnection in the 1990s. In addition, special access remains an important carrier-to-carrier service.

In future NOIs, the Commission should inquire about the scope of all the above COLR duties. The information obtained and the analysis thereof will ensure that the Commission understands the historical proportions of COLR status in promoting ubiquitous voice service, and thereby will better inform the Commission's efforts to promote ubiquitous broadband service, to deal with carrier exits, and to ensure continuity in carrier-to-carrier services.

2. The Commission Should Build a New Broadband POLR Policy in Partnership with State Commissions

After completing its inventory of existing state COLR policies, the Commission should apply that knowledge to define the duties that will be assigned to broadband POLRs receiving federal funding. The Commission should consider separately each of the traditional components of voice COLR duties, such as duty to serve, exit conditions, service quality, network standards and carrier-to-carrier obligations. In this way, the Commission's policies regarding broadband will be designed to achieve public benefits commensurate with those historically generated by state COLR policies regarding the voice network.

The appropriate relationship between the Commission and the states will be a central issue in the design of a new broadband POLR system. An important threshold question is whether states should be preempted from exercising regulatory oversight similar to their historical COLR duties or whether those roles should be reaffirmed for broadband. The Nebraska Companies propose the Commission should not automatically conclude that it is the agency best suited to administer all parts of the new broadband POLR system. The best answer might be an allocation of responsibilities between state and federal agencies. There might be one allocation of authority for defining broadband POLR duties, another allocation for assigning service areas to POLRs, and a third allocation for enforcing violations of POLR duties.

In deciding these federalism questions, the Commission should also consider history. COLR policy originated with state law, and before that with common law.[171] Such state authority still exists, except as it may have been preempted by federal law.[172] Therefore, many state commissions still have state law authority to extend COLR policies to broadband telecommunications providers, to assign franchise or service areas, and to enforce the assigned obligations. The Commission should commence its federalism analysis with the assumption that many states have sufficient authority under state law to define and properly administer broadband POLR duties.

A relatively greater involvement of the states also makes sense in terms of the greater local knowledge and resources of state commissions. States have unique access to local facts and circumstances, and are most knowledgeable about the capabilities of existing networks and providers. The Commission is unlikely to achieve its broadband goals without strong support from states, acting in a capacity consistent with their traditional COLR role.

In deciding the federalism questions, the Commission should also consider its enabling statute. Section 214(e) of the Telecommunications Act places constraints on possible federalism

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[171] *See* P. Bluhm and P. Bernt, *Carriers of Last Resort: Updating a Traditional Doctrine,* National Regulatory Research Institute, Report 09-10, July, 2009, p.15.

[172] Although the Commission has broadly declared broadband Internet services to be interstate information services, the preemptive effect on state COLR policy is not clear. Also, some states have enacted laws limiting their own authority over broadband services. On the other hand, TA96 offered states the opportunity to apply many COLR-like roles in defining eligibility for federal universal service funding by Eligible Telecommunications Carriers. *See* 47 U.S.C. § 214(e). The Nebraska Commission has opened a docket to consider whether it has jurisdiction to collect and disburse Nebraska Universal Service Fund support for construction of broadband facilities. This issue has not yet been resolved.

options. This section assigns to states the primary responsibility to designate ETCs and to define their service areas.[173] This is consistent with a number of other broad delegations to the states, including:

- Managing carrier exits (under the rubric "relinquishment of universal service");[174]
- Assigning a common carrier to an unserved community;[175]
- Exempting rural telephone companies[176] and "2% carriers"[177] from expanded interconnection obligations;
- Deciding whether collocation is not practical due to space limitations; and[178]
- Arbitrating interconnection disputes.[179]

These statutory delegations of authority to state commissions have a common theme. Each recognizes the unique abilities of state commissions to make decisions based on detailed knowledge of local facts and customs.

In deciding the federalism questions, the Commission should also consider its own resource limitations. It is difficult to conceive how the Commission could realistically undertake the task of assigning broadband POLR duties to hundreds of individual carriers, defining their

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[173] 47 U.S.C. §§ 214(e)(2), (e)(5).

[174] 47 U.S.C. § 214(e)(4).

[175] 47 U.S.C. § 214(e)(3).

[176] 47 U.S.C. § 251(f)(1)(B) (requires consideration of whether a request is unduly economically burdensome, is technically feasible, and is consistent with section 254).

[177] 47 U.S.C. § 251(f)(2)(A) (requires consideration of whether exemption is necessary to avoid a significant adverse economic impact on users of telecommunications services generally, to avoid imposing a requirement that is unduly economically burdensome; or to avoid imposing a requirement that is technically infeasible).

[178] 47 U.S.C. § 251(c)(6).

[179] 47 U.S.C. § 252(b).

service area boundaries, episodically adjusting those boundaries, episodically abating POLR duties within localized areas where competition makes a return on voice network investment unlikely, and enforcing all of the resulting obligations. The time commitments required of the Commission staff would appear to be unsustainable.

States historically have performed all these tasks. State commissions are accustomed to determining detailed factual questions using contested proceedings, including setting and adjusting the boundaries of service areas. State commissions also have an established record of enforcing COLR duties.

A fundamental task will be to define the incentives the Commission will offer to states and to define performance expectations for those states that accept the incentives. The incentives should be sufficient to generate cooperation from the great majority of states.

Allocating the many components of a broadband POLR policy will necessarily be a complex task. Nevertheless, the Commission should not be tempted by less rigorous shortcuts. For example, the Commission might consider administering POLR duties itself using paper proceedings and dispensing with live cross-examination, site visits and public hearings. While less costly, a paper proceeding would be unlikely to prove satisfactory. The finder of fact would never see the area, would never give the public an opportunity to be heard, and would have only limited information about the scope and quality of the networks that currently serve the area.

An even less desirable shortcut would be to conduct "procurement auctions" [180] in which bidders are allowed to define their own service areas. Such a procurement auction would place customers at risk because no public official would make any findings on the supported carrier's

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[180] *NOI*, paras. 44-45.

service area, and there would likely be no consideration of local conditions and needs. For example, a procurement auction with user-defined service areas could leave broad gaps in broadband coverage. Also, a procurement auction system could generate business failures by incumbent broadband or voice providers, leaving many customers without both voice and broadband service and without a carrier to offer default service. Without a geographic area to which it applies, a "duty to serve" would be meaningless.

When it comes to enforcing POLR duties, states have stronger incentives than the Commission itself. If an area is unserved or service is interrupted, the Nebraska Companies believe that state commissions are far more likely to receive complaints from customers, and are far more likely to be motivated to take an active interest in solving the problem.

All of these historical, resource, incentive, and procedural arguments suggest that states should have a significant role in assigning broadband POLR service areas, just as is currently the case for voice COLR duties and for federal ETC designations. This recommendation is also compatible with 47 U.S.C. § 214(e), which requires support recipients to be designated as ETCs to serve areas designated by the state commissions. Similarly, states should have an important role in defining and enforcing broadband POLR duties.

3. To Protect Consumers, the Commission Must Manage COLR Issues in the Transition to Broadband USF

As the Commission adapts the present universal service system to a new system that supports only broadband, its third major task will be to manage the replacement of traditional COLR duties with a new set of broadband POLR duties. The benefits secured by voice COLR policy, including nearly ubiquitous rural voice service, could be harmed during this interim period. The harm could arise either from prematurely abating existing COLR duties or by making policy decisions that make it financially impossible for voice COLRs to continue providing service.

The Commission has anticipated some transition problems. The National Broadband Plan postulates that a provider other than the ILEC might be selected as the broadband POLR. In that event, the Commission has said that it would have to decide "how rights and responsibilities should be modified."[181] The Commission also noted that there could be other kinds of support for past network investment by incumbent carriers.[182]

During the transition, the Commission also needs to decide whether traditional state functions should continue to be observed. Specifically, the Commission should decide whether, during the transition, states continue to have authority to:

- Determine when a voice COLR or broadband POLR must extend facilities to subscribers;
- Adjust COLR, POLR and ETC service area boundaries;
- Abate the duty to serve in competitive areas; and
- Supervise carrier exits and apply mass migration rules.

All of these questions are complicated by the fact that some networks provide only broadband, some only voice, and some both.

D. The Commission Should Establish Collaborative Relationships with State Commissions and Utilize Existing and Potential State USF Programs

Although some states already had USF support programs in 1995, the 1996 amendments to the Communications Act expressly authorized establishment of state USFs and also prescribed

[181] *National Broadband Plan*, p. 149. The *National Broadband Plan* fails to note that this would in most cases be a question for state law. *See Broadband Gap Paper*, p. 38.

[182] *Id*., p. 151.

a funding mechanism for such funds.[183] The courts have gone further, holding that the 1996 amendment to the Communications Act "plainly contemplates a partnership between the federal and state governments to support universal service."[184]

The *NOI* and other recent Commission publications say little about the role of states in administering the Commission's contemplated new support mechanisms. The Commission should clarify its views about the interaction of federal and state USF support, and it should take the initiative now to set up collaborative mechanisms so that a working partnership on universal service can be developed.

1. The Commission Should Avoid Harming Existing State USF Programs

Twenty-one states currently have USF support programs. About half of these programs are cost-based. Many of these state programs are intended to fill funding gaps between costs and federal program support.[185] Some programs use federal support as an input for calculating state support. For example, one state increases support automatically to compensate for any decreases in federal USF support.[186] Before it makes policy changes to its own USF programs, the Commission should gather information regarding state USF programs and the likely impacts of federal USF changes on those state programs. Without that knowledge, a federal policy change

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[183] 47 U.S.C. § 254(f).

[184] *Qwest Corp. v. FCC*, 258 F.3d 1191, 1203 (2001).

[185] When determining each qualified carrier's state support, the Nebraska Universal Service Fund, for example, imputes that carrier's federal USF revenue in the earnings calculation.

[186] The Oklahoma Universal Service Fund is one of two universal service funds operated by that state. The OUSF has a unique provision in its "Primary Universal Service" program that allows rural ILECs to recover any future revenue loss caused by state or federal regulatory actions. *See* P. Bluhm, P. Bernt and J. Liu, *State High Cost Funds: Purposes, Design, and Evaluation*, National Regulatory Research Institute, Jan. 2010, NRRI Paper No. 20-04 at 36, note 101.

could inadvertently make the Commission's own programs ineffective or could generate needless tension with state USF programs.

2. The Commission Should Promote Financial Partnerships with State USF Programs

A sound partnership with the states can also extend the reach of limited federal financial resources. The Commission has announced that the Broadband Gap is $23.5 billion. State USF support can help to fill this gap.

The Commission's apparent plan to further reduce the access and USF revenue of incumbent carriers makes the USF support challenge even more difficult. If those announced changes do occur, substantial state funding may be essential for the Commission to comply with the statutory requirement that support be sufficient to achieve reasonably comparable services and rates in rural areas.

Other federal agencies routinely require that states match federal funding in order to receive grants. Matching is required in a range of program areas, including highways, education, and health care. These other agencies often find that state funds multiply the effect of limited federal budgets. The Commission has previously used the matching funds technique when it sought to expand the Lifeline program.[187]

Some state commissions are ready for this kind of cooperation. California already has an established program for broadband. At least one other state is currently considering adopting such a program.[188] If the Commission wants to develop a state financial partnership, it must

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[187] *Federal-State Joint Board on Universal Service*, Report and Order, FCC 97-157, para. 351 (released May 8, 1997).

[188] In the Matter of the Petition of the Nebraska Telecommunications Association for Investigation and Review of Processes and Procedures Regarding the NUSF, Application No. NUSF-77, before the Nebraska Commission (opened Jan. 26, 2010).

consult with state commissions. This work could be performed through NARUC, the Universal Service Joint Board, the Section 706 Joint Conference or some combination of these organizations.

Future NOIs should seek comment on the best practices for promoting financial partnerships between state and federal USF programs. The Commission should specifically inquire as to whether:

- Support should be reduced if the state does not generate a minimum level of state USF funding for broadband;
- The Commission should create financial or other incentives for states to generate universal service funds as authorized by 47 U.S.C. § 254(f); and
- States or carriers should receive other incentives in return for generating state funds, such as preference in grant programs, more rapid deployment of broadband to unserved areas, lower monthly subscribership rates in high cost areas, or greater control over program administration.

V. CONCLUSION

The Nebraska Companies respectfully request the Commission to carefully consider, adopt and incorporate, as appropriate, the positions set forth in the foregoing Comments into its efforts to implement the National Broadband Plan and to direct Connect America Fund support to accomplish such implementation.

Dated: July 12, 2010

Respectfully submitted,

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ATTACHMENTS

Attachment A: Vantage Point Study (with Appendices)

Attachment B: Summary of the Nebraska Universal Service Fund High-Cost Program

Attachment C: Map of Nebraska illustrating County Boundaries and Service Areas of Incumbent Local Exchange Carriers

ATTACHMENTS

Attachment A: Vantage Point Study (with Appendices)

Nebraska Rural Independent Companies

An Engineering Analysis of the Broadband Assessment Model Using Actual Network Data

July 2010

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1 Executive Overview

Vantage Point Solutions (Vantage Point)[1] has studied the assumptions and analysis presented in "The Broadband Availability Gap, OBI Technical Paper No. 1"[2] (OBI No. 1), which was attached to the recent USF NOI/NPRM.[3] The OBI No. 1 explains how the cost, or investment gap, to provide broadband access to locations that are currently unserved was calculated. Broadband, for purposes of the analysis, is defined as the ability to achieve 4 Mbps downstream and 1 Mbps upstream (4/1 Mbps) with a reasonably high probability of success. Using this standard, the OBI No. 1 estimates that there are approximately 130 million housing units in the United States and that approximately 7 million are without broadband. These unserved housing units are "overwhelmingly in rural areas"[4] and fixed Wireless using Long Term Evolution (LTE) and Digital Subscriber Line (DSL)[5] technologies were determined to be the most economical networks for broadband delivery to those areas. The OBI No. 1 recognized performance and capability issues associated with satellite broadband and therefore determined that only the highest-cost customers should be served using satellite.[6]

In order to test the accuracy of the OBI No. 1 model results, several areas of rural Nebraska were analyzed. Detailed wireline and wireless engineering designs were drafted for these areas. The cost and performance estimates were then compared to the conclusions of the OBI No. 1. Although many parts of the OBI No. 1 are well researched and many of the individual facts are correct, Vantage Point's analysis uncovered significant flaws in the engineering principles used and found several conclusions reached in the OBI No. 1 to be incorrect.

1.1 The OBI Model Does Not Use Standard Engineering Practices

1.1.1 Assumed Data Rate is Not Adequate

The National Broadband Plan set the universal broadband speed target at 4/1 Mbps.[7] This target was based on the assumption that a household only requires 1 Mbps downstream today[8] and that 4 Mbps downstream would provide some "headroom against rapid obsolescence."[9] Even if 1 Mbps downstream were presumed adequate currently, using a 26% growth rate,[10] it will take only six years for demand to exceed the 4/1 Mbps target. If this plan were adopted, broadband demand would likely exceed the

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[1] Vantage Point staff has over 400 years of combined experience with performing both wireless and wireline design and engineering for service providers serving rural areas. See Vantage Point Background in Appendix A of this document or visit www.vantagepnt.com.
[2] The Broadband Availability Gap, OBI Technical Paper No. 1, Federal Communications Commission, April 2010.
[3] In the Matter of Connect America Fund, A National Broadband Plan for Our Future High-Cost Universal Support, FCC 10-58, Released April 21, 2010.
[4] OBI No. 1, p. 20.
[5] OBI Model assumes copper loop lengths of 12,000 feet using 24 AWG cable.
[6] OBI No. 1, p. 41.
[7] Federal Communications Commission, Connecting America: The National Broadband Plan, released Mar. 16, 2010, (National Broadband Plan), p. 135.
[8] OBI No. 1, pp. 42-43.
[9] Id., p. 43.
[10] Id., p. 42.

capabilities of 4 /1 Mbps networks by the time the rules are finalized, the contracts are awarded, and the networks are built. Constructing networks with such a short useful life would be shortsighted, costly and an inefficient use of scarce USF resources.

Even though the OBI No. 1 contends that customers today only need 1 Mbps downstream, the authors also admit that more than 89% of the households in the United States have more than 10 Mbps downstream available and over 94% have in excess of 6 Mbps downstream available.[11] Most major multiple system operators (MSOs) have deployed 100 Mbps services in some of their markets. Comcast, the largest MSO with 16 million broadband subscribers, plans to roll out 100 Mbps service in all of its markets by the end of 2011.[12] Rural customers who are only able to receive 4/1 Mbps will not be able to take advantage of broadband applications that require these higher speeds. Without adequate broadband, rural residents will have restricted access to information and markets for goods and services and, consequently, will become second-class citizens in this digital age.

1.1.2 Network Dimensioning Analysis in OBI Technical Paper is Flawed

The assumption of a Busy Hour Offered Load (BHOL) of 160 kbps in the OBI No. 1 is inappropriate. While the authors of the OBI No. 1 note that an average BHOL of 444 kbps would be required for users to achieve burst speeds of 4 Mbps,[13] instead of designing a network capable of accommodating 444 kbps, they disregard the heaviest 10% of users, even though these users usage represents 65% of the network load.[14] Although incorrect, ignoring the heaviest users allowed a BHOL of only 160 kbps to be used for network sizing.[15]

Service providers can use management techniques to mitigate the impact of heavy users. However, reducing the assumed BHOL by over 63%, from 444 kbps to 160 kbps, will result in a network where the possibility of achieving 4/1 Mbps by any user would be unacceptably low. This approach of removing the heaviest users under the assumption that their traffic can and will be throttled using network management techniques runs counter to the National Broadband Plan's goal of providing ubiquitous broadband service.

Underestimating BHOL skews the analysis toward limited capacity technologies, such as LTE, and often results in a design that is significantly lower in cost than a design based on a reasonable BHOL. An underestimation of the BHOL rarely has the same effect on DSL networks, since they do not suffer from the same capacity limitations as LTE–especially in rural environments. DSL network capacity is not shared until the traffic reaches the Digital Subscriber Line Access Multiplexer (DSLAM) uplink and even then would rarely result in oversubscription in sparsely populated rural areas. Reducing the BHOL from 444 kbps to 160 kbps would have little or no impact on the design or cost of a DSL network, but would

[11] Id., p. 17.
[12] Comcast: 100-Meg Residential Service Coming This Year, Multichannel News, 3/17/2010, http://www.multichannel.com/article/450400-Comcast_100_Meg_Residential_Service_Coming_This_Year.php
[13] OBI No. 1, Exhibit 4-BS, p. 113. Vantage Point agrees that 444 kbps could be realistic when attempting to achieve 4 Mbps with today's traffic patterns.
[14] Id., p. 111.
[15] Id., p. 111.

artificially reduce the cost of an LTE network, potentially making LTE appear cost-effective when it might not otherwise be if an appropriate BHOL were used. Designing an LTE network for a BHOL of 160 kbps would result in a network that would not meet the 4 /1 Mbps objective of the National Broadband Plan.

In addition, real-time traffic, such as teleconferencing, remote medical procedures, VoIP, and video is becoming a larger percentage of the overall Internet traffic. This type of traffic places significant demands on a service provider's network. Capacity limited networks–especially those that have shared capacity in the access network such as LTE–will have significant capacity constraints. These traffic patterns will require a network designed with a larger BHOL if acceptable network performance it to be maintained.

1.1.3 Errors in Calculation of LTE Bandwidth Capabilities

The OBI No. 1 showed the spectral efficiency of LTE to be between 1.36 and 1.5 bps/Hz,[16] which means that a sector's capacity is between 1.36 and 1.5 times the spectrum used. Using the high end of this range, 5 MHz of spectrum would make 7.5 Mbps of capacity available.[17] The OBI No. 1 also shows the theoretical maximum for LTE to be approximately 1.8 bps/Hz.[18] Nonetheless, the OBI design assumes a spectral efficiency of 1.92 bps/Hz, which is higher than the theoretical maximum. The effect of this assumption is to understate the cost of an LTE network artificially.

With 2x20 MHz of spectrum (20 MHz for upstream and 20 MHz for downstream) and a three sector cell site, the OBI calculated that there can be 650 subscribers per cell site. The OBI states that 29 to 37% of these customers (188 to 240 customers) could simultaneously obtain a 460 Kbps video stream. For that to be possible, between 90.24 and 115.2 Mbps of capacity would have to be available, which would require a spectral efficiency of 1.92 bps/Hz. Using actual LTE spectral efficiencies, only 81.6 to 90 Mbps of capacity will be available, so only 170 to 187 customers (not 188 to 240 customers) would be able to enjoy a 480 kbps video stream simultaneously. An inappropriately high spectral efficiency assumption results in understating tower costs since the analysis calculates that more customers will be adequately served by a tower than actually can be.

1.2 Nebraska Case Study Conclusions

Vantage Point conducted studies of exchanges located within the serving areas of Great Plains Communications (GPC) and Consolidated Companies in order to compare the results of the OBI model with actual network designs. Both of these companies serve customers in the State of Nebraska.

1.2.1 The OBI Model Does Not Accurately Represent Served and Unserved Areas

In comparing OBI No.1, Exhibit 2-B[19] to the exchange areas in the Nebraska case studies, it appears that in many areas, the model is inaccurate for estimating the current availability of 4/1 Mbps services. In

[16] Id., Exhibit 4-E, p. 64.
[17] 5 MHz X 1.5 bps/Hz = 7.5 Mbps.
[18] Id., p. 64.
[19] Id., p. 18.

the GPC and Consolidated case studies, the model overestimated availability by about 50% and underestimated availability in others by about 30%.

For wireline service, the OBI model equates estimated DSL availability with the network's capability of providing DSL service at a speed of 4/1 Mbps. It does not appear that the model considers the costs to provide the middle mile broadband capacity. This assumption is flawed when applied to small, rural companies, for whom middle mile and backbone costs are especially high, and results in misclassification of some served and unserved areas. Companies that serve areas where middle mile costs are high may avoid utilizing their networks to full capacity in order to economize on expensive connections.

1.2.2 The OBI Model Does Not Accurately Determine Upgrade Costs

To determine the accuracy of the OBI Model, Vantage Point compared the investment requirements of its engineering designs for the areas under consideration to those calculated by the OBI Model. Figure 1-1 shows a comparison of the OBI and Vantage Point case study investments.

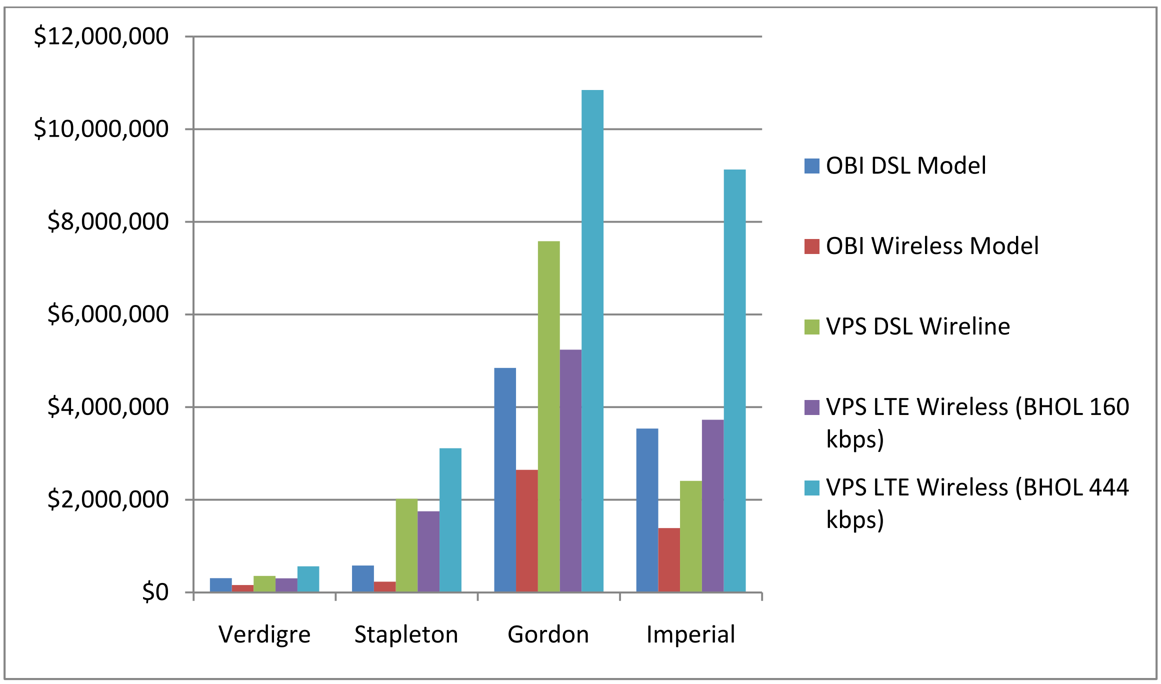


Figure 1-1: Comparison of OBI and Case Study Investment Estimates

As can be seen, the OBI Model was inaccurate at predicting costs when compared with actual network designs. In all areas explored with actual network designs, wireline networks were shown to be less expensive than BHOL 444 kbps wireless networks.

1.2.3 LTE is Not a Cost Effective Fixed Broadband Solution

The results of the GPC case studies indicate that the initial investment of a 4/1 Mbps DSL wireline design (no oversubscription or 4 Mbps BHOL) is lower than an LTE wireless (9:1 oversubscription or 444 kbps

BHOL) design. The wireless 160 kbps BHOL design (25:1 oversubscription) is not shown because such a network would not be capable of reliably providing 4 Mbps services.[20] Table 1-1 is a summary of the initial investment estimates for DSL wireline and 444 kbps BHOL wireless designs.

	Exchange	DSL Wireline (4/1 Mbps BHOL – No Oversubscription)	LTE Wireless (444 kbps BHOL – 9:1 Oversubscription)
Investment	Verdigre	$ 355,000	$ 560,000
	Stapleton	$ 2,020,000	$ 3,110,000
	Gordon	$ 7,580,000	$ 10,850,000
	Imperial	$ 2,405,000	$ 9,130,000
Totals		**$ 12,360,000**	**$ 23,650,000**

Table 1-1: 4/1 Mbps Wireline and Wireless Initial Investment Comparison

As shown in Table 1-1, the wireline DSL initial investments are on average 48% lower than wireless LTE investments.

	Exchange	DSL Wireline (4/1 Mbps BHOL – No Oversubscription)	LTE Wireless (444 kbps BHOL – 9:1 Oversubscription)
Investment	Verdigre	$ 740,000	$ 1,465,000
	Stapleton	$ 3,180,000	$ 7,055,000
	Gordon	$ 11,455,000	$ 21,590,000
	Imperial	$ 4,710,000	$ 21,770,000
Total		**$ 20,085,000**	**$ 51,880,000**

Table 1-2: 4/1 Mbps Wireline and Wireless 20-Year Investment Comparison

When considered over a twenty-year lifetime, the wireline designs are, on average, 61% less expensive than the wireless designs as shown in Table 1-2.

One reason why wireline DSL is less expensive than LTE is that DSL can make better use of existing infrastructure. For example, in Imperial, a GPC exchange, a significant amount of the fiber required to upgrade DSL infrastructure is already in place. Thus, the upgrades required to increase broadband speeds can be implemented at a relatively low cost.

Additionally, the wireless designs require significantly more new towers than were assumed in the OBI Model. In the case studies, new towers were needed at least 68% of the time and up to 92% of the time for some design scenarios. The OBI Model states that on a national basis, new towers would be required in only 15% of the cases.[21] In areas without towers, the OBI Model assumed that 52.5% of the time, existing structures, such as grain silos or steeples, could be found in suitable locations. Vantage Point investigated this assumption in the GPC exchanges and found practically no existing structures that would be appropriate substitutes for wireless towers. In western Nebraska, where housing

[20] Refer back to Section 1.1.2 for an explanation of why 160 kbps BHOL network design is incapable of 4 /1 Mbps service.

[21] OBI No. 1, pp. 81-82.

densities of less than one housing unit per square mile are common and grain is not stored in silos, the assumption that suitable structures will be found is not practical. The GPC case studies demonstrate that the OBI Model significantly underestimates the number of new towers that must be built, and thus materially understates the cost of the LTE network.

The DSL wireline designs in these case studies are not only less expensive, but also have superior performance when compared to fixed wireless LTE designs. The DSL wireline designs have no oversubscription of broadband speeds in the access network, allowing all customers to access 4/1 Mbps broadband simultaneously. In contrast, the LTE wireless designs have an oversubscription ratio of 9:1 when assuming a BHOL of 444 kbps. Thus, the wireline DSL designs have at least nine times the network capacity of the wireless LTE designs.

Consider several customers simultaneously utilizing telecommuting or file sharing applications. In a DSL wireline design, one customer's broadband use would have no impact on other users' available broadband speed, since there is no oversubscription. In a wireless design, however, other customers would experience a sizable drop in broadband speed when a customer uses a bandwidth-intensive application. Assuming a 9:1 oversubscription ratio (BHOL of 444 kbps) and 7.5 Mbps available per wireless sector, each sector can serve 16 locations. Consequently, if just two customers in a sector both utilize an application consuming 3 Mbps, only 1.5 Mbps would remain for the other 14 households combined.

An additional benefit of the 4/1 Mbps wireline designs is that customers located close to the DSL electronics[22] have the capability of broadband speeds much higher than 4/1 Mbps due to increased broadband speed capability over shorter twisted-pair copper cable distances.

Since many subscribers' broadband needs are already greater than 4/1 Mbps, Vantage Point compared the twenty-year investment costs of 20 Mbps and 100 Mbps wireline designs with a wireless 4/1 Mbps design. As shown in Table 1-3, not only do the wireline designs provide superior service and speed, but also they are less expensive than wireless.

	Exchange	20 Mbps DSL/FTTP Wireline Design	100 Mbps FTTP Wireline Design	4 Mbps LTE Wireless (444 kbps BHOL – 9:1 Oversubscription)
Investment	Verdigre	$1,265,000	$3,315,000	$ 1,465,000
	Stapleton	$5,375,000	$6,770,000	$ 7,055,000
	Gordon	$14,925,000	$21,555,000	$ 21,590,000
	Imperial	$10,780,000	$19,790,000	$ 21,770,000
Total		**$32,345,000**	**$51,430,000**	**$ 51,880,000**

Table 1-3: Twenty-Year Investment for High Capacity Wireline Designs and 4/1 Mbps Wireless

[22] Electronics are located either in the central office or in a remote cabinet.

2 Current and Future Customer Demands

2.1 Broadband Trends

The broadband of today is the narrowband of tomorrow. Less than ten years ago, a 56 kbps modem was the most common method for accessing the Internet. Today, consumers are demanding broadband speeds in excess of 10 or even 20 Mbps. Many experts agree that customers will want 100 Mbps broadband speeds within the next five years and 1 Gbps within the next ten to fifteen years. Nielson's law, which assumes a growth rate of 50% a year for high-end users, has proven largely correct over the past decade, and speeds are expected to continue to rise at similar or greater rates.[23] Customers' expectations are increasing and a wide variety of rich media applications are now a de facto part of everyday culture.[24] According to the U.S. Internet Industry Association, "…the significant increases in Internet Demand come from the fast-rising use of broadband applications, especially video and music/voice, which require much greater bandwidth than email text or normal web browsing."[25] The demand for broadband is increasing so rapidly that data traffic is now being measured in Exabytes.[26] Cisco expects Internet traffic (including delivery of content to television and mobile phones) to reach about 56 Exabytes per month by 2013, up from just 9 Exabytes in 2008.[27] Higher bandwidth requirements for Internet applications and increased numbers of devices connected to the Internet have driven the growth in Internet traffic.

Goal No. 1 of the National Broadband Plan envisioned 100 million U.S. homes to have affordable access to actual speeds of at least 50/20 Mbps by 2015 and at least 100/50 Mbps by the year 2020.[28] Goal No. 4 of the National Broadband Plan envisioned that anchor institutions such as schools, hospitals, and government would have affordable access to 1 Gbps broadband access. The National Broadband Plan also stated that, "once community anchors are connected to gigabit speeds, it would presumably become less expensive and more practical to get the same speeds to homes."[29] Both of these goals demonstrate the Commission's awareness that Internet speeds much faster than 4/1 Mbps are becoming an essential part of modern life.

In Figure 2-1, dial-up and broadband speeds commonly available to United States residents, the majority of whom live in metropolitan areas, were plotted on a logarithmic scale from 1980 through the year 2020. The growth of dial-up Internet appears almost linear, as does the growth in broadband speeds. The chart shows that broadband speeds of 4 Mbps downstream were commonly available in the United

[23] Andrew Marshall, White Paper: Future Bandwidth Requirements for Subscriber and Visitor Based Networks, p. 4.
[24] White Paper: Future Bandwidth requirements for subscriber and visitor based networks, Campus Technologies, Inc. December 2007.
[25] Robert Shapiro, "The Internet's Capacity to Handle Fast-Rising Demand for Bandwidth, http://www.usiia.org/pubs/Demand.pdf, p. 9.
[26] One Exabyte is 10^{18} bytes, or one-million Gigabytes.
[27] Ben Worthen, "Cisco Says Internet Video to Explode" Wall Street Journal Digits [blog], June 9, 2009.
[28] National Broadband Plan, p. 25.
[29] National Broadband Plan, p. 26.

States about eight years ago. Extrapolating current speeds to future years, shows that broadband demand could reach 1 Gbps by 2020.

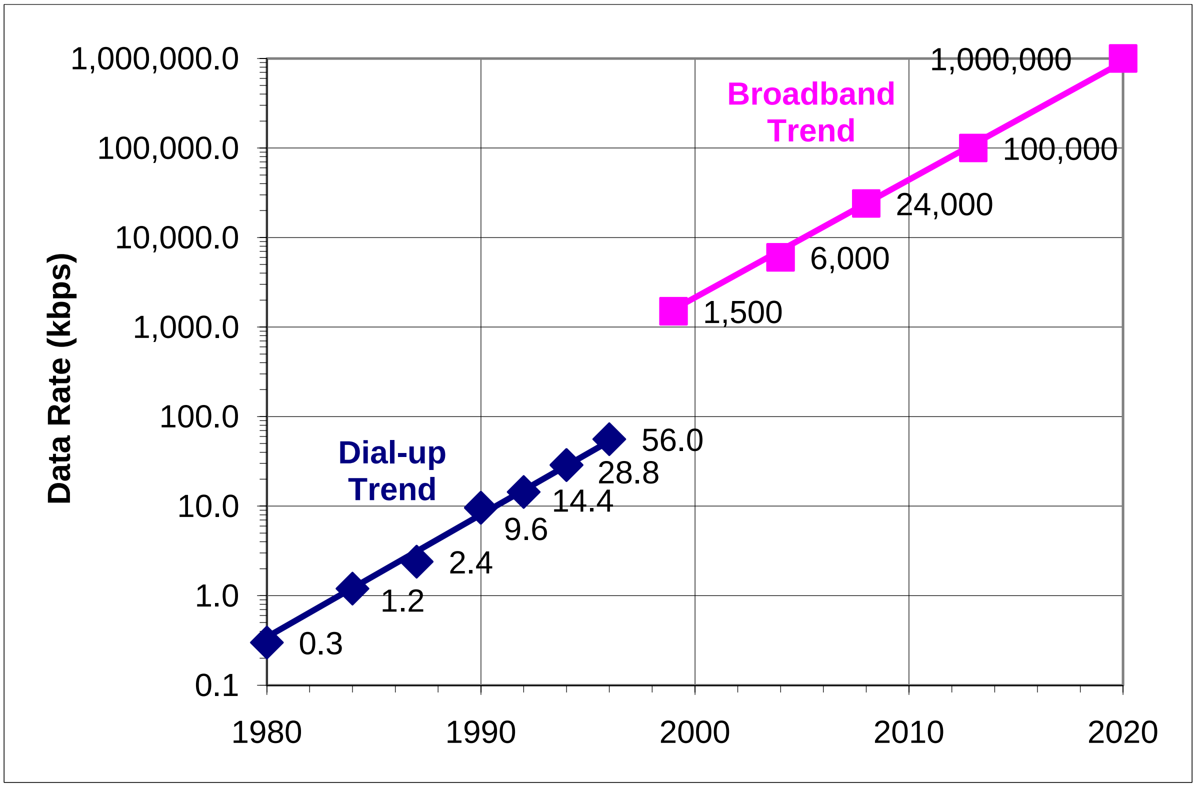
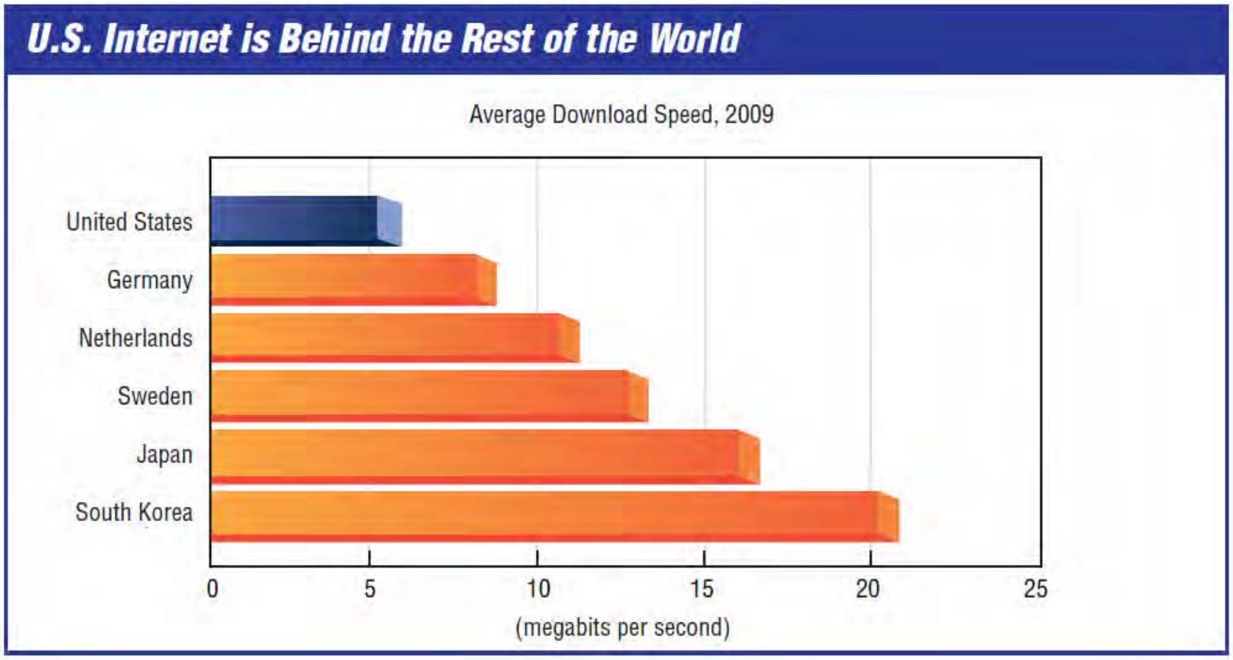


Figure 2-1: Historical and Future Internet Access Bandwidth for Metropolitan Areas

Although demand for broadband in the United States is growing, the United States is falling behind other developed countries in broadband penetration and speed. As of the end of 2009, the OECD annual broadband Internet statistics show the United States ranked 15th among the group's thirty member countries for broadband penetration and 24th in average advertised speeds.[30] As shown in Figure 2-2, countries such as South Korea, Japan, the Netherlands, and the Scandinavian nations are outperforming the United States in average download speeds. Japanese subscribers can upload a high-definition video in 12 minutes, compared to a grueling 2.5 hours for the average American user, yet, the Japanese pay about the same for Internet as American customers.[31]

[30] Organization for Economic Cooperation and Development (OECD), Broadband subscribers per 100 inhabitants and Average broadband speeds by country (2009), OECD Broadband statistics [oecd.org/sti/ict/broadband].
[31] Speed Matters, Affordable High Speed Internet for America, 2009.



Sources: U.S. data is from speedmatters.org test results. International data from speedtest.net.

Figure 2-2: Average Download Speeds

In response to the OECD rankings in 2007, FCC Commissioner Michael Copps stated:

> Every year brings more bad news as the United States slides farther down the broadband rankings. It's a national embarrassment and the only way to change it is to develop a broadband strategy like every other industrialized nation has already done. These rankings aren't a beauty contest–they're about our competitiveness as a country and creating economic opportunity for all our people. Bringing high-speed broadband to every corner of the country is the central infrastructure challenge we face. Always in the past, our nation found ways to stay ahead of everyone else in building infrastructure like turnpikes, railroads and highways. Now, in broadband, we're not even an also-ran.[32]

[32] Commissioner Copps Reiterates Call For A National Broadband Strategy To Address America's Drop In Broadband Rankings, FCC News Release, April 23, 2007.

World-class broadband is essential for the United States to be able to effectively compete in the new world economy. Broadband is becoming the lifeblood of our economy. *The Economist* asserts:

> In eras past, economic success depended on creating networks that could shift people, merchandise and electric power as efficiently and as widely as possible. Today's equivalent is broadband: the high-speed Internet service that has become as vital a tool for producers and distributors of goods as it is for people plugging into all the social and cultural opportunities offered by the web. Easy access to cheap, fast Internet services has become a facilitator of economic growth and a measure of economic performance.[33]

The appetite for broadband will continue to grow, especially as more devices are connected to the Internet. The amount of bandwidth required per user will also continue to increase and there is no end in sight.

2.2 Broadband Applications and Drivers

As new, bandwidth-intensive applications are developed and more devices become Internet enabled, customers' broadband speeds will need to increase. Popular Internet applications used today include the following:

- Internet Based Applications (such as Google Docs, Office applications, and online backups)
- Video Conferencing/Telepresence
- Smart Grid Applications
- Telemedicine
- Modern Communication and Social Networking (such as Facebook, MySpace, Flicker, and VoIP)

These applications and many others have rich content and therefore require ever increasing broadband speeds. An adequately sized broadband connection is required to use these applications effectively. Broadband is necessary for many aspects of life, including communication, commerce, and increasingly medical services. Many of the broadband applications most suited to rural areas, such as diagnostic telemedicine and high-quality distance learning and telecommuting, do not function well with connection speeds of less than 5 Mbps, and 10 Mbps or more is preferred.[34] Availability of higher broadband speeds allows for delivery of new, exciting applications. Some of these applications are shown in Table 2-1.

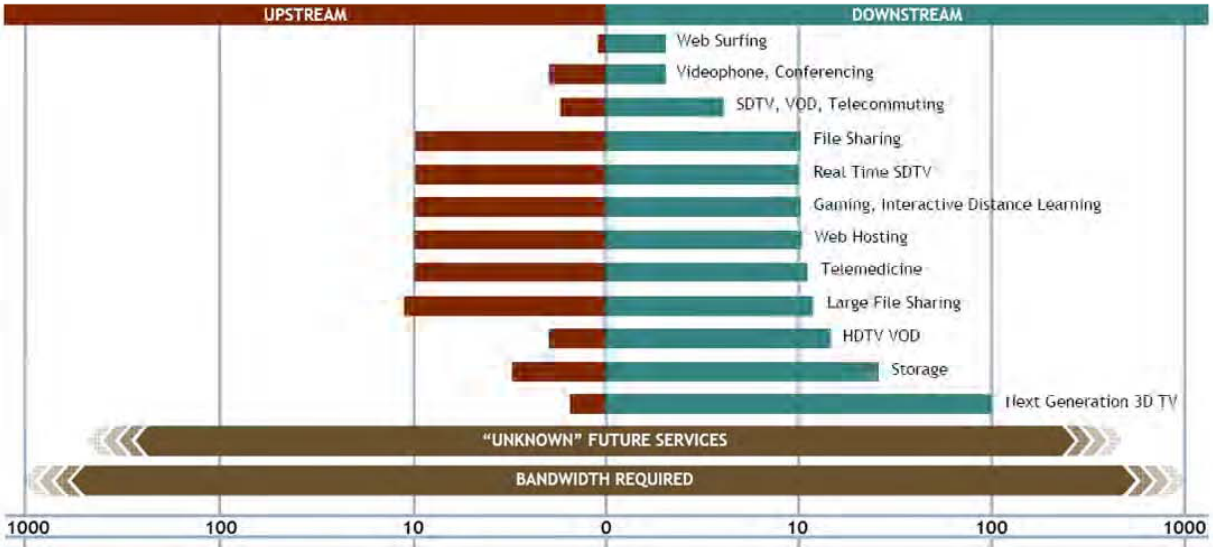
[33] The Economist, *Broadband Access*, January 17, 2008.
[34] http://linkwyoming.org/lwy/default.aspx?page=15 .

Broadband Speeds	Applications
500 kbps – 1 Mbps	Voice over IP, texting, basic e-mail, web browsing (simple sites) streaming music (caching), low quality video (highly compressed and on a small screen)
1 Mbps – 5 Mbps	Web browsing (complex sites), e-mail (larger size attachments), remote surveillance, Standard Definition IPTV, file sharing (small/medium), telecommuting (ordinary), streaming music
5 Mbps – 10 Mbps	Telecommuting (converged services), file sharing (large), Standard Definition (SD) IPTV (multiple channels), High Definition (HD) video downloading, low definition telepresence, gaming (graphical), medical file sharing (basic), remote diagnosis (basic), remote education, building control & management
10 Mbps – 100 Mbps	Telemedicine, educational services, SD and HD IPTV, gaming (complex), telecommuting (high quality video), high quality telepresence, HD surveillance, smart/intelligent building control
100 Mbps – 1 Gbps	HD telemedicine, multiple educational services, gaming (immersion), remote server services for telecommuting
1 Gbps – 10 Gbps	Research applications, telepresence using uncompressed HD video streams, live event digital cinema streaming, telemedicine remote control of scientific/medical instruments, interactive remote visualization and virtual reality, movement of terabyte datasets, remote supercomputing

Adapted from California Broadband Task Force, January 2008

Table 2-1: Broadband Speeds and Connections

Clearly, the broadband of today is not adequate as the broadband of tomorrow. Over the last ten years, consumer demand for higher broadband speeds has grown even more rapidly than most experts projected and high growth rates are expected to continue. Even though downstream bandwidth demand is increasing at breakneck speeds, upstream bandwidth is growing even faster as user-generated content becomes more widespread. The demand for higher broadband speeds in both upstream and downstream directions is demonstrated in Figure 2-3.



Source: Calix

Figure 2-3: Estimated Broadband Application Upstream and Downstream Rates (Mbps)

As applications that demand higher broadband speeds are adopted, the broadband speeds per household will also have to increase. Based on industry projections of broadband growth[35] and its own experience with the customer bandwidth demands, Vantage Point expects residential household broadband speed to grow significantly in the next couple of years, as shown in Figure 2-4. Vantage Point anticipates that 100 Mbps per household will be required by 2013 and demand could grow even larger with the requirements of 3-Dimensional High Definition TV (3D HDTV).

[35] See Figure 2-1.

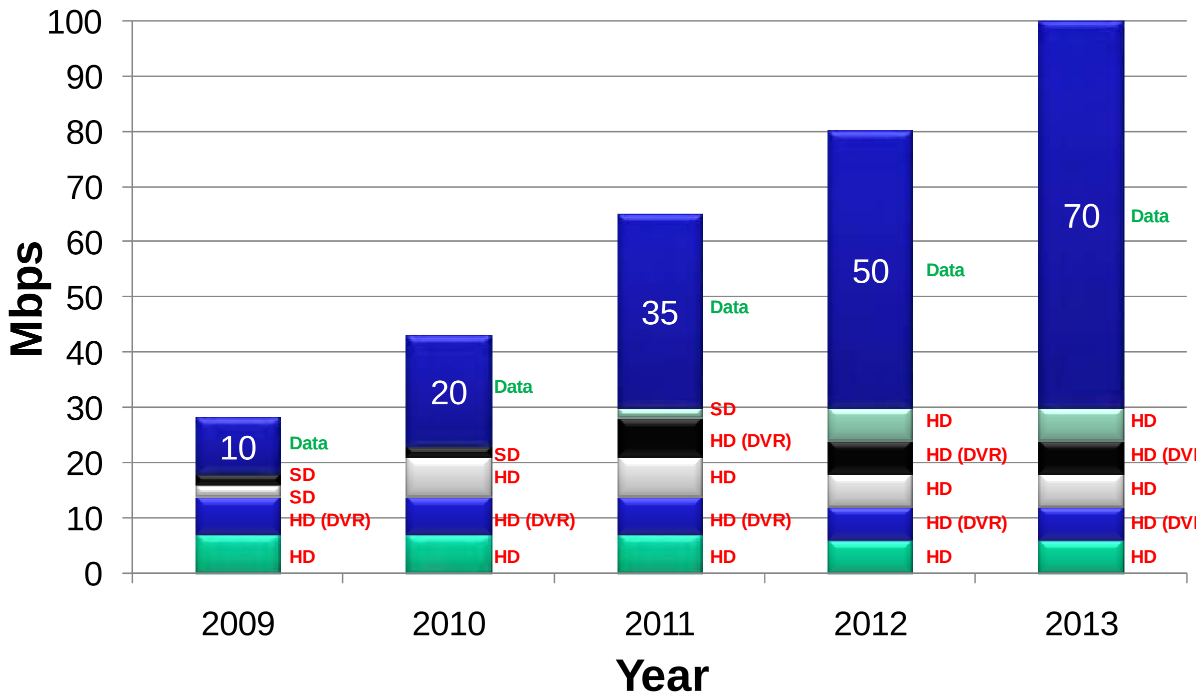


Figure 2-4: Broadband Demand Trends–Single Households

With new broadband-intensive applications being introduced and with customers deploying multiple applications, the demand for higher broadband speeds continues to increase in both urban and rural areas.[36] Given growing broadband demand, the NBP target of 4/1 Mbps will be obsolete in a few years and likely is outmoded already. A 4/1 Mbps target would leave rural residents far behind compared to their urban counterparts who can receive broadband that is at least 25 times faster.[37]

2.3 The Role of Wireless and Wireline Broadband

Both wireless and wireline broadband service providers have benefited from technology advances, however *wireline* technologies have historically been capable of speeds many times faster than the best *wireless* technologies. Rysavy Research stated it this way, "Given that the inherent capacity of one fiber optical link exceeds the entire available radio frequency (RF) spectrum, data flow over wireless links will never represent more than a small percentage of the total global communications traffic."[38]

[36] Additional information regarding customer broadband demands and practical methods for delivering broadband to customers can be found in the attached whitepaper in Appendix C titled, "PROVIDING WORLD-CLASS BROADBAND: The Future of Wireless and Wireline Broadband Technologies."
[37] Julius Genachowski, NARUC Conference, Washington, DC, February 16, 2010. This substantial gap will occur if indeed 100 Mbps broadband reaches 100 million, presumably urban households.
[38] Rysavy Research, *EDGE, HSPA, and LTE Broadband Innovation, 3G Americas*, p. 5, September 2008.

Both wireless and wireline broadband services play important roles in many customers' lives and one will never displace the other. Today's customers expect that broadband carriers will be able to offer a plethora of applications in a variety of locations. The wireline connection is required to provide adequate bandwidth for the rich multimedia experience customers expect in their home or business,[39] and a wireless connection is required to meet customers' mobile needs.[40] As Rysavy research notes, "sometimes wireless and wireline technologies compete with each other, but in most instances they are complementary."[41]

To understand the complementary nature of wireless and wireline broadband service, one need not look further than observing the habits of the Millennial Generation (Millennials are typically defined as the generation born after 1980). A study conducted by Alcatel-Lucent concluded that service providers' success would depend on their ability to offer "content, communication and applications anywhere, at any time, on any device."[42] Millennials take an active approach to technology:

> They want to be able to add, subtract and change key elements of technology offerings and find new ways of using their tools to advance their personal and professional objectives. As a result, they expect their phones, music players and notebook PCs to share data and applications (interoperability), and they will reward any player in the market who helps them organize and manage their different technological investments from a centralized platform.[43]

Not only are wireline and wireless services complementary in the lives of their customers, but they are also complementary in the sense that wireless service depends on the speed and quality of wireline connections. To meet the mobile broadband needs of their customers, the major wireless carriers will migrate their networks to 4th Generation wireless technologies (4G). In order for this to occur, wireless towers will require high capacity connections, typically using Ethernet delivered over a landline carrier's fiber network.

The various technologies for deploying broadband differ in cost and quality. The quality of a broadband connection is primarily determined by five metrics: speed (size of the "pipe"), packet loss, jitter, latency (delay), and reliability. To realize all the benefits of broadband, customers must have a high-quality connection that meets their needs today and in the future. Compared with wireless networks, wireline networks offer superior performance in these metrics.

2.4 Broadband Deployment in Rural Areas

From the service provider's perspective, the networks deployed today must be easily scalable to meet the broadband needs of tomorrow without significant additional investment. For both wireless and wireline broadband access networks, much of the infrastructure has a twenty-year life, or longer. If the a service provider were to construct a network that fails to meet customer's needs after a few years, the

[39] Customers' fixed needs include cloud computing, telecommunicating, and video applications.
[40] Customers' mobile needs include email, messaging, and social networking.
[41] Rysavy Research, *EDGE, HSPA, and LTE Broadband Innovation, 3G Americas*, p. 5, September 2008.
[42] J. Giere, *Millenmials: The Future is Now*, ALU Enriching Communications Magazine, Volume 2, Issue 1, 2008.
[43] Id.

cost to provide broadband would likely be considerably greater since a second network would have to be designed and built before the first network had reached the end of its economic life. In these instances, the network that appears to be the least expensive initially may be more expensive in the end because of upgrades or network replacements that must occur.

Deploying broadband in areas of low customer density presents its own challenges, because the infrastructure cost per customer can be up to ten times greater than in urban areas. In rural areas, it is especially important that the infrastructure deployed be easily scalable to meet the customer's future broadband needs, since the replacement cost is so high. Then acting FCC Chairman Michael Copps recognized this when he stated, "Bandwidth-intensive applications could very quickly become the norm in the U.S.–even in rural areas. Technologies that cannot be upgraded easily could make Internet applications less than five years from now look like the dial-up downloads of today."[44]

In order to have broadband speeds in rural areas that are comparable to speeds available in urban areas, the carriers' investments will be large, but the cost of failing will be even larger.

[44] Federal Communications Commission, *Bringing Broadband to Rural America: Report on a Rural Broadband Strategy*, Michael J. Copps, Acting Chairman, May 22, 2009.

3 Broadband Access Technologies

Broadband technologies can be broken down into two categories:

1. Wireline Technologies – Technologies that rely on a physical cable for transmission of the communication signal. These cables usually transport an electrical signal on a copper cable or an optical signal on a fiber optic cable.
2. Wireless Technologies – Technologies that transmit the communication signal "over the air" using radio frequencies (RF).

These technologies can be further broken down into the following network architectures:

1. Digital Subscriber Line (DSL) – This wireline technology overlays a broadband signal on existing twisted pair copper cables. Broadband speeds on DSL networks are dependent on the customer's distance from electronics in remote terminals or central offices.
2. Fiber to the Premises (FTTP) – This wireline technology serves all customers by a fiber optic cable. Most FTTP equipment allows 70 Mbps to 1 Gbps of broadband to each customer and is capable of serving customers that are more than twelve miles from the central office or electronic field terminal locations.
3. Long Term Evolution (LTE) – This wireless technology is still in its infancy and has not had significant deployments. For these purposes, Vantage Point assumed that 700 MHz spectrum would primarily be used due to its superior propagation characteristics. Since LTE is just now being deployed, it is not as well tested as DSL and FTTP. Vantage Point believes that LTE can be deployed in rural areas, but possibly not for a couple years, as it will take time for equipment to become available and cost effective for deployment.

3.1 Wireline Broadband Access Overview

Wireline broadband providers can deploy broadband services to their customers using either DSL or FTTP technologies. As will be shown, wireline broadband providers have the ability to provide significantly higher data speeds to their customers than is possible with wireless providers.

3.1.1 Digital Subscriber Line (DSL)

Telephone companies have historically provided voice service over twisted pair copper cable. Consequently, millions of miles of twisted pair copper cable have been deployed. DSL technologies allow carriers to deliver broadband service to customers over these existing copper cables. Due to the physical characteristics of the copper cable, a network's capability is heavily dependent upon cable length. Customers who live close to central offices or remote terminals can receive much higher broadband speeds than those who live farther away.

To increase broadband speeds, service providers have been moving electronics closer to the customer. These electronics are normally connected to the central office using fiber optic cable. Figure 3-1 shows that DSL networks are normally divided into serving areas, with subscribers near the central office being served directly and the remaining subscribers being served from remote terminals. The size of the serving area is dependent on the type of DSL technology being used and the bandwidth required by the customer.

The most common DSL technologies, defined and standardized by the ITU-T,[45] are Asymmetrical Digital Subscriber Line (ADSL) and Very-high-bit-rate Digital Subscriber Line (VDSL) with the latest variants of these technologies being ADSL2+ and VDSL2. When using DSL technologies, cable length is normally limited to 12,000 to 16,000 feet for 4/1 Mbps service.

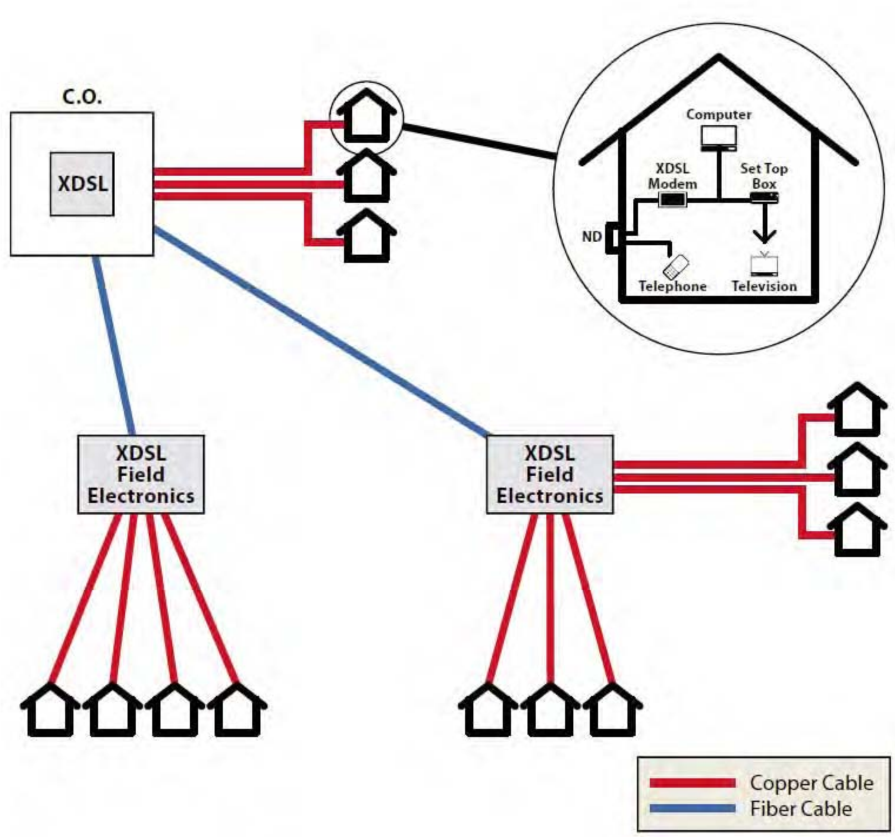


Figure 3-1: DSL Network Topology

DSL has been an effective broadband technology for more than 15 years. Nevertheless, most service providers realize that DSL will not be a long-term solution for broadband delivery and have been looking to fiber technology to meet increasing demand.

[45] International Telecommunication Union (ITU)–Telecommunication Standardization Sector.

3.1.2 Fiber to the Premises (FTTP)

Fiber optic cable has been used by service providers for more than thirty years to build high-speed broadband networks, primarily for long haul transport routes. More recently, fiber has also been used to increase broadband speeds to the customer because no other technology can deliver as much broadband speed. With FTTP,[46] the broadband speed provided is not dependent upon cable length, and each new generation of FTTP electronics allows service providers the ability to offer significantly higher broadband speeds over greater distances. There is no foreseeable end to the amount of bandwidth that can be provided over fiber cables. Today, there are two main competing FTTP technologies: Gigabit-capable Passive Optical Network (GPON) and Active Ethernet. Vendors are now making Wavelength Division Multiplexing Passive Optical Network (WDM-PON), which promises even greater broadband speeds. Each FTTP technology will be discussed briefly below.

Most GPON implementations use optical splitters to serve up to 32 subscribers using a single fiber from the central office. GPON technology is defined by the International Telecommunications Union (ITU) standards and currently allows for 2.4 Gbps downstream and 1.2 Gbps upstream. This bandwidth is shared by 16 or 32 customers. Under a "worst-case" scenario when all customers are demanding their maximum broadband speed, each customer could be limited to 75 Mbps downstream and 37.5 Mbps upstream. A future advancement of GPON, 10GPON, is expected to provide a four-fold increase in broadband speed. A typical PON system is shown in Figure 3-2.

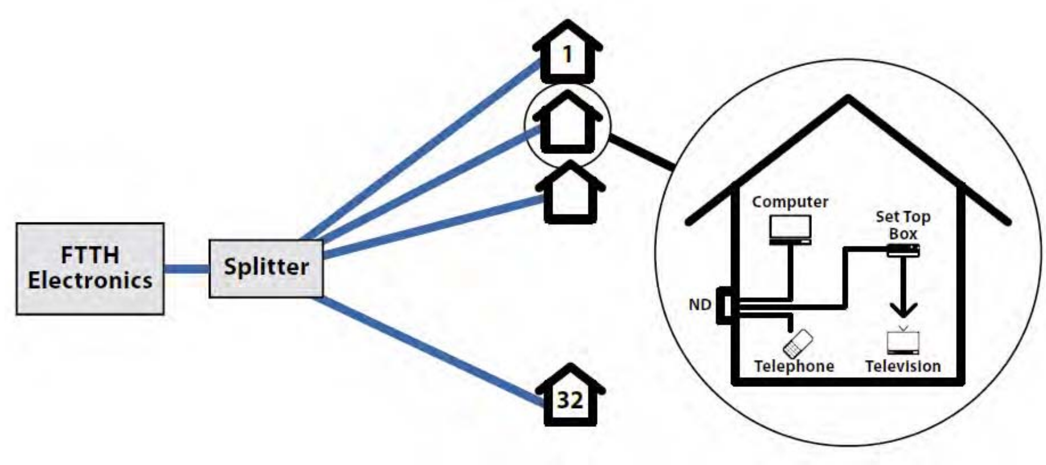


Figure 3-2: PON System

Active Ethernet systems use a dedicated fiber between the central office and the customer, so the broadband consumption of one customer does not affect the amount of broadband available to other customers. In addition, Active Ethernet systems are symmetrical, meaning they provide equivalent downstream and upstream rates. Today, most Active Ethernet systems can provide up to 1 Gbps to each subscriber, more than ten times the broadband available on a GPON system. Active Ethernet systems have not been as widely deployed as GPON systems in the United States, since they are typically

46 Fiber-to-the-Premises is sometimes referred to as Fiber-to-the-Home (FTTH).

more expensive. As subscriber broadband demand increases, Active Ethernet systems are becoming more common. An Active Ethernet system is shown in Figure 3-3.

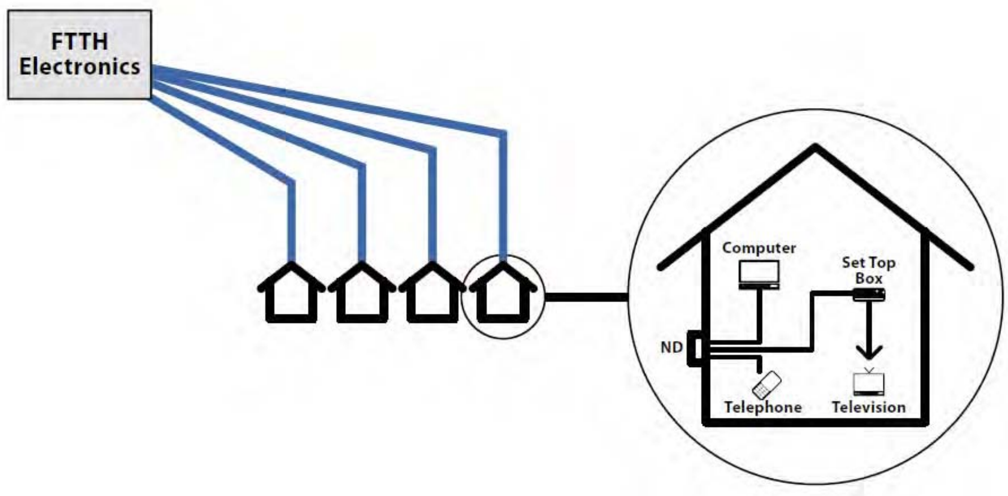


Figure 3-3: Active Ethernet

WDM-PON technologies are similar to both GPON and Active Ethernet. On a WDM-PON, a single fiber cable can serve multiple customers, like GPON, and individual customers have their own dedicated wavelength on the fiber, like Active Ethernet. In some configurations, a small number of customers on a PON share a wavelength. Adding wavelengths on a PON network has the effect of multiplying the effective broadband to the customer. A WDM-PON system is depicted in Figure 3-4. WDM-PON is an example of how advancements in electronics can leverage an existing fiber network to provide almost limitless broadband potential.

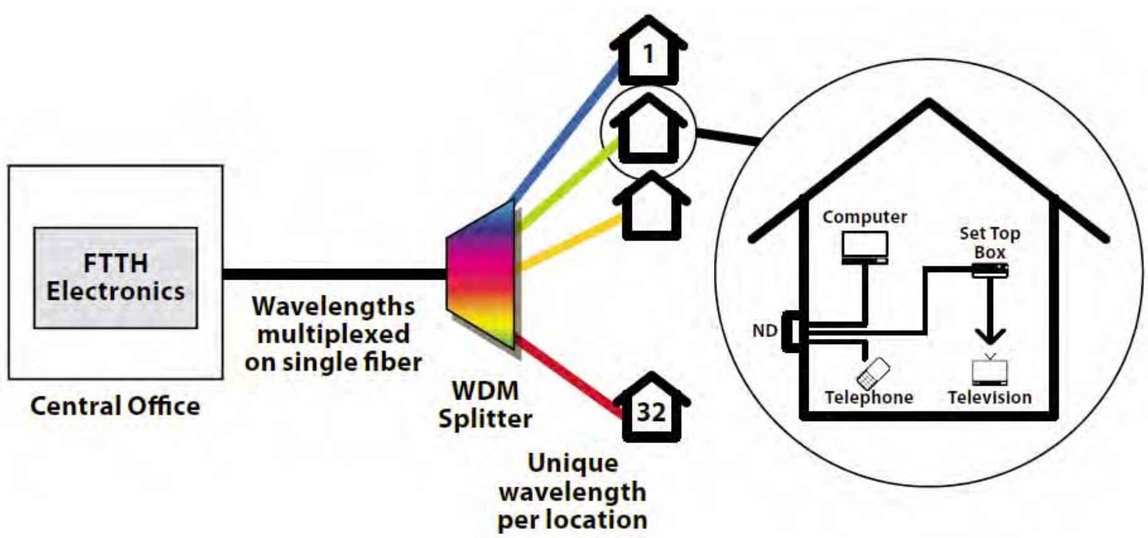


Figure 3-4: WDM-PON System

3.2 Wireless Broadband Access Overview

Wireless broadband has become a requirement for many consumers. What began with simple text messaging has grown to include web browsing, file transfer, and video streaming. There are many ways that a wireless provider can deliver a broadband service to its customer. Each method varies in cost and quality. For purposes of this paper, Vantage Point focuses its attention on LTE in the 700 MHz band.[47]

3.2.1 Mobile and Fixed Wireless Broadband

Historically, there have been two distinct groups of wireless carriers–those focused on serving the mobile user and those focused on serving the fixed (stationary) user. Normally, fixed wireless carriers can provide greater broadband speeds to their customers, but at the sacrifice of mobility. As depicted in Figure 3-5, both mobile and fixed wireless technologies are converging on what is referred to as a 4th Generation (4G) network, an all-IP network having the throughput of fixed wireless along with the mobility of mobile wireless. There are currently two dominant 4G wireless technologies: Mobile-WiMAX and LTE.

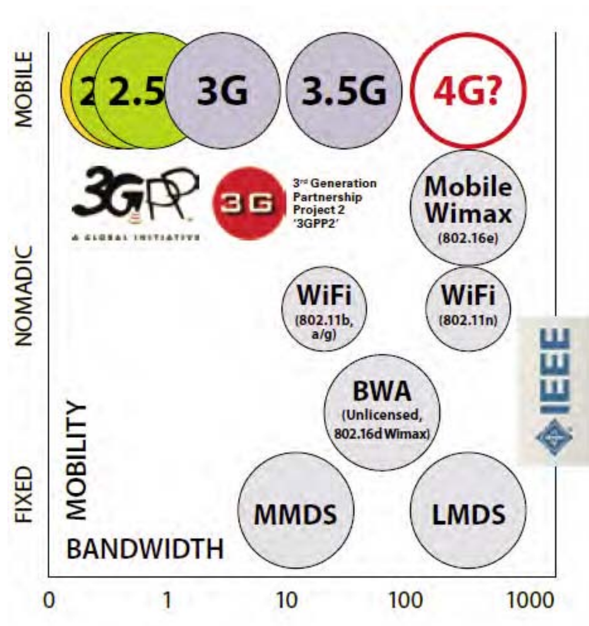


Figure 3-5: Cellular and WLAN Converge on 4G

[47] The user of the 700 MHz spectrum band corresponds with assumptions made in OBI No. 1.

The ITU has tentatively defined 4G, which it calls "IMT-Advanced," as 1 Gbps capability for stationary users and 100 Mbps for mobile users, although a typical customer would realize only a small fraction of this throughput. The throughput achieved by wireless technologies is dependent upon many factors:

- Customer's Location – As the customer's distance from the tower increases, the speed of the connection decreases.
- Available Spectrum Bandwidth – More spectrum bandwidth means higher connection speeds.
- Frequency of Spectrum – Generally, the higher the frequency the shorter the propagation distance.
- Presence of Obstacles – Obstacles, such as trees, hills and buildings, attenuate wireless signals and can reduce or prohibit broadband.
- Environmental Effects – Some operating frequencies are highly susceptible to attenuation due to rain, fog, or snow, which reduces the broadband speed.
- Order of spatial diversity – The configuration of Multiple Input, Multiple Output (MIMO) antenna technology can affect the throughput.
- Customer Premises Antennas – The type and gain of the antennas can affect the achievable bandwidth.

Wireless carriers in the United States rely primarily on spectrum allocated by the FCC in the 700 MHz, 850 MHz (Cellular), 2 GHz (PCS and AWS) and 2.5 GHz (BRS/EBS) licensed bands. Many carriers have spectrum in several of these frequency bands. Future 4G technology improvements will allow carriers to make spectrum from multiple bands appear as a single broadband channel. Consistent with the OBI No. 1 assumptions,[48] today's "4G" technologies can achieve a typical spectral efficiency of 1.5 bps of actual throughput per Hz of spectrum bandwidth. Thus, a carrier with 10 MHz of spectrum could potentially deliver 15 Mbps to its customers. However, since wireless technologies share bandwidth among many customers the total bandwidth is divided among the customers. For example, if 100 customers were to share 15 Mbps, each would effectively receive 150 Kbps if all were using the system at the same time.

[48] OBI No. 1, Figure 4-E, p. 64.

4 Great Plains Communications Case Studies – Design of Wireline and Wireless Networks

Vantage Point performed case studies for the Great Plains Communications (GPC) exchanges of Verdigre, Stapleton, Imperial and Gordon. GPC is a Local Exchange Carrier (LEC) that serves 26,500 access lines across Nebraska. The GPC service area is large and most of it is very sparsely populated. In total, GPC's service territory covers about 14,000 square miles. If the GPC service area were its own state, it would be larger than nine of the states. The exchanges that were studied are geographically dispersed across the state of Nebraska. Additionally, some of these exchanges cover large portions of counties, and therefore can be compared with the OBI No.1 availability information. For these case studies, wireline and wireless networks were designed and engineered with the goal of providing a minimum of 4/1 Mbps broadband service to all households. Vantage Point consulted closely with GPC engineering personnel for the project design. The cost estimates were based on recent Vantage Point and GPC outside plant, tower, and electronics project costs. The designs were based on existing customer locations only, since the areas are not experiencing population growth.

Network Design Assumptions Regarding Oversubscription

Designing a communications network where customers share a common communications channel often involves "oversubscription." For broadband networks, oversubscription occurs when the total amount of broadband capacity offered to customers is greater than the total available network capacity. In other words, the "offered load" (the amount of traffic users try to place on the network) is greater than the "carried load" (the amount of traffic the network can carry). For example, if a DSLAM with a 100 Mbps uplink serves 200 customers who each have 10 Mbps broadband service, the oversubscription would be 20:1. So, for every 20 Mbps of bandwidth offered to customers, there is 1 Mbps available in the DSLAM uplink to carry traffic. Generally, a lower oversubscription ratio, such as 15:1 rather than 20:1, results in better performance, but other network characteristics affect performance for a given oversubscription ratio. These network characteristics include the following:

- Number of Customers Sharing the Communication Channel – Rural networks serving small numbers of customers require network designs with lower oversubscription ratios than would be appropriate for networks designed for more customers. When fewer customers are sharing network resources, the probability is greater that a higher percentage of the customer base will want to use the network resources at the same time. To achieve good network performance, the "offered load" to each customer must be substantially smaller than the total "carried load," as seen in Exhibit 4-BT of the OBI No. 1.[49] Therefore, as the number of customers in Exhibit 4-BT is reduced from 2,500 to 500 and eventually to 100, the oversubscription ratio must be reduced from 25:1 down to 17:1 to maintain a 90% probability of achieving 4 Mbps or greater broadband speed. Since many of the unserved customers are located in areas with twenty or fewer customers served by a DSLAM or by a sector of a wireless network, the oversubscription ratio is important. As the number of customers served decreases, the oversubscription ration must be

[49] OBI No. 1, Exhibit 4-BT, p. 113.

decreased to provide the same level of performance. The OBI No. 1 analysis appeared to ignore this engineering issue, but it could be significant in practice.

- Type of Traffic – As traffic transitions to streaming traffic–such as video conferencing, video, medical imaging–rather than bursty traffic, the oversubscription ratio must be reduced to maintain the desired broadband speed. Using the previous example, when 200 customers are offered 10 Mbps service, or a 2,000 Mbps "offered load," and are sharing a 100 Mbps uplink, these customers have a high probability of achieving 10 Mbps service if their traffic demands are sporadic and bursty. If just twenty of these customers, or 10% of the total, require a 5 Mbps data stream, the uplink will be completely filled, leaving 90% of the customers without any available broadband capacity. Since streaming traffic is becoming a larger portion of network usage, the oversubscription ratio must be reduced to maintain a given broadband speed. Networks that can easily expand capacity, such as wireline networks, will be better able to adapt to changing traffic patterns.

The two terrestrial networks considered in the OBI No. 1 were a 12,000-foot DSL network and a wireless LTE network.[50] These networks have substantially different oversubscription characteristics. A DSL network relies on dedicated copper wires from the DSLAM to the customer. Since a customer is not sharing the wires with any other customer, there is no oversubscription. The first network point where there could be oversubscription is the DSLAM uplink. In the Vantage Point case studies of GPC exchanges, all DSLAMS are served by fiber optic cable. With twenty customers served by a DSLAM (almost twice as many as the average DSLAM in this analysis), the total uplink capacity needs to be 80 Mbps to ensure there is sufficient capacity. Since all DSLAMs in the GPC case studies assumed 1 Gbps uplinks, sufficient capacity would be available in the DSL access network.

From an oversubscription standpoint, a wireless LTE network is quite different from a wireline DSL network. Rather than copper wires, the LTE network uses radio waves as the access medium and all users in the sector share the radio spectrum. Unlike the bandwidth available on a fiber cable, the radio spectrum is a limited resource and very bandwidth constrained. Today, LTE networks can achieve a spectral efficiency of approximately 1.5 bps/Hz; therefore, 5 MHz of spectrum would have a total capacity of only 7.5 Mbps. If the network were designed with no oversubscription, only one 4 Mbps customer would be allowed per sector. Thus, the only practical way to deploy a wireless network is to design it with oversubscription. However, oversubscription results in reduced network performance, especially when customers use streaming applications and when a single customer's offered bandwidth is a significant percentage of the channel bandwidth.

Wireline Network Designs Used in the Case Studies

Vantage Point designed three wireline networks for the case study exchanges:

- **4 Mbps Design (No Oversubscription) –** As described in Section 2 of this document, 4 Mbps is not adequate to meet customer broadband needs today, much less in the future. Nevertheless,

[50] Id., p. 62.

to provide a comparison with the OBI No. 1, a 4/1 Mbps network was designed.[51] In the four exchanges, GPC has existing 4/1 Mbps network capability in the towns and areas immediately surrounding the towns. Utilizing ADSL2+ DSL access technology and 14,000 foot serving areas,[52] the rural areas required the addition of remote electronic cabinets to provide 4/1 Mbps service. All investment required for the DSL access network, including construction of fiber to these additional remote electronic cabinets was included in the designs. There is no oversubscription in the access network.

- **20 Mbps Design (No Oversubscription) –** To understand the costs associated with increasing the network capacity due to increased user demands, a 20 Mbps design was developed. This design represents the broadband capabilities readily available in most urban areas today, and Vantage Point believes that this design should be the minimum broadband capability in rural areas. Because the towns included in these case studies have relatively short copper distances, GPC would be able to provide 20 Mbps utilizing ADSL2+. Providing 20 Mbps over ADSL2+ in the rural portions of these exchanges would not be economically feasible due to the large number of remote cabinets needed to serve relatively few subscribers. Therefore, a FTTP design using dedicated buried cable was used for the rural areas. Like other DSL designs, this design has no oversubscription in the access network.
- **100 Mbps Design (No Oversubscription) –** To estimate the cost of a network that would meet projected broadband demand for the next five years, a 100 Mbps network was designed for all town and rural subscribers. In this design, FTTP technology was used with no oversubscription in the access network.

GPC Existing Outside Plant Characteristics

With the existing outside plant infrastructure and minimal investment, GPC is able to provide 4/1 Mbps broadband service to customers who live within an approximate 14,000-foot serving area from each central office or remote terminal utilizing ADSL2+ DSL technology. This serving area distance has been confirmed by actual testing and electronics vendor data. GPC has predominantly good quality 24 AWG, as well as some 22 and 19 AWG copper plant. GPC primarily uses Adtran electronics in its access network. Adtran provided downstream and upstream ADSL2+ rate and reach tests using 24 AWG copper with an increasing numbers of self disturbers in the same binder group. Figure 4-1 shows the Adtran downstream test results.

[51] Id., p. 42.

[52] The rationale behind 14,000-foot serving areas is described in “GPC Existing Outside Plant Characteristics” within this section.

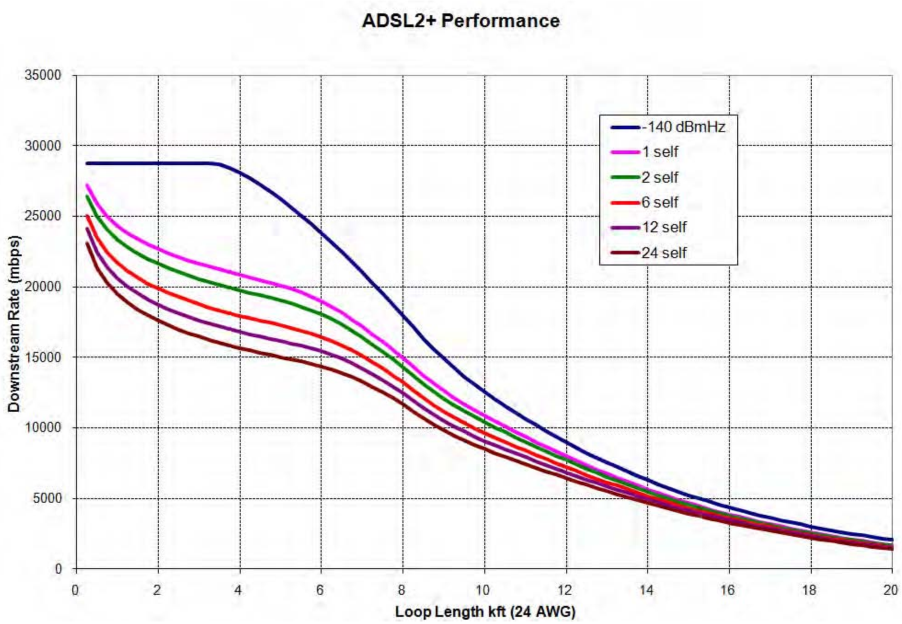


Figure 4-1: ADSL2+ Downstream Rate/Reach Test Data

As evident in Figure 4-1 above and Table 4-1 below, a downstream bandwidth of 4 Mbps can be achieved to a distance of at least 15,000 feet even with a large number of interferers in the same cable binder. While Adtran's testing involved 24 AWG cable, as was assumed in the OBI No. 1, the portions of GPC's network with 19 and 22 AWG cable could achieve 4 Mbps at even greater distances.

Distance (kft)	1 Self Disturber (Mbps)	2 Self Disturbers (Mbps)	6 Self Disturbers (Mbps)	12 Self Disturbers (Mbps)	24 Self Disturbers (Mbps)
12.00	7.99	7.72	7.22	6.85	6.46
12.25	7.67	7.42	6.95	6.60	6.22
12.50	7.35	7.12	6.67	6.35	5.99
12.75	7.05	6.83	6.41	6.10	5.76
13.00	6.75	6.54	6.15	5.86	5.54
13.25	6.46	6.27	5.90	5.62	5.31
13.50	6.17	5.99	5.65	5.38	5.09
13.75	5.89	5.73	5.40	5.15	4.88
14.00	5.63	5.47	5.17	4.94	4.67

Table 4-1: Downstream ADSL2+ Rate/Reach Test Results

The Adtran testing also shows that for high quality 24 AWG loops, 1 Mbps upstream can be delivered to 14,000 feet, as can be seen in Table 4-2.

Distance (kft)	Rate (Mbps)
12.00	1.40
12.25	1.39
12.50	1.38
12.75	1.37
13.00	1.35
13.25	1.34
13.50	1.33
13.75	1.32
14.00	1.30

Table 4-2: Upstream ADSL2+ Rate/Reach Test Results

Based on the Adtran data and Vantage Point engineering experience, Vantage Point concluded that 4/1 Mbps service could be provided at cable distances up to 14,000 feet from the electronics. In addition, if there were an isolated location where the 4/1 Mbps rate was not achievable, GPC would be able to utilize bonded ADSL2+ technology to provide service with minimal additional cost. Within areas served by FTTP, broadband speeds significantly greater than 4/1 Mbps can be delivered.

Wireless Network Designs Used in the Case Studies

The wireless designs developed in these studies were based on the Third Generation Partnership Project (3GPP) Release 8 Technical Standards for a LTE network operating in a 2 X 2 Multiple Input-Multiple Output (MIMO) configuration. Consistent with the assumptions of the OBI No. 1,[53] a spectral efficiency of 1.5 bps/Hz per sector was assumed.

For purposes of the 4/1 Mbps design, 10 MHz (2 x 5 MHz) of spectrum was assumed to be available in the 700 MHz band. Obtaining 20 MHz of contiguous spectrum in the 700 MHz band would be extremely difficult for any company, especially a small rural company, such as GPC. A comparison of the prices paid in earlier FCC Auctions for 700MHz spectrum to the most recent FCC Auction 73, shows the cost to acquire a license has increased significantly. For example, CMA 535–Nebraska 3–Knox sold in September 2002 for $44,000 in Auction 44. The same CMA market in March 2008 sold for $3,437,000 in Auction 73. The price increase in Auction 73 had a direct impact on the fair market value of the 700 MHz spectrum. For a company to obtain licensed 700MHz spectrum, it would have to find a willing seller and be willing to pay the current fair market value. These factors make it difficult for companies to acquire spectrum at reasonable prices. While companies could potentially purchase spectrum in other bands, such spectrum would not have the same propagation characteristics as the 700 MHz spectrum and, therefore, would be more costly to deploy.

All RF predictions for the GPC exchanges are downlink predictions modeled utilizing Hata-Okumura Parameters and 1” National Elevation Dataset (NED) Terrain and Clutter files downloaded from the USGS website with a resolution of approximately 30 meters. Copies of the RF predictions are included in Appendix B.

[53] Id., Exhibit 4-E, p. 64.

For the wireless portion of the studies, three network designs were evaluated:

- **4 Mbps Design with BHOL=160 kbps (25: 1 Oversubscription)** – This design corresponds to the BHOL scenario of 160 kbps from the OBI No.1. Since each sector has a capacity of 7.5 Mbps,[54] 46 households could be served by each sector. Vantage Point believes a 160 kbps BHOL assumption is flawed because 10% of the customers were eliminated from the analysis. These users, whom the OBI ignored, comprise 65% of the total network demand.[55] Vantage Point does not believe that a BHOL assumption of 160 bps is credible since households would not achieve 4/1 Mbps service for a reasonable percentage of the time. No spectrum costs were included in this scenario; inclusion of spectrum costs would obviously add to the overall cost.
- **4 Mbps Design with BHOL=444 kbps (9:1 Oversubscription)** – This design is based on the current average BHOL of 444 kbps from the OBI No. 1. In this scenario, the 7.5 Mbps of capacity in each sector can serve 16 households. This design has a higher probability of providing 4 Mbps to the households; however, the individual user's broadband speed still represents a large portion of the channel bandwidth. As a result performance issues may be expected especially during the busy hour. As Internet traffic transitions to more streaming applications, performance will further decline. As in the 4 Mbps design, no spectrum costs were included in this scenario; inclusion of spectrum costs would add to the overall cost.
- **4 Mbps Design (9:1 Oversubscription with Additional Spectrum)** – In this scenario, it is assumed that an adjacent 2 x 5 MHz of 700 MHz spectrum and 2 x 5 MHz of other spectrum (AWS, PCS, etc.) could be obtained and used. The combined 22.5 Mbps[56] of capacity can serve 49 households in each sector. This analysis represents the 444 kbps BHOL scenario from the OBI No. 1, which includes the usage of all customers. Again, since individual user's bandwidth is a large portion of the channel bandwidth and because much of the Internet traffic is now streaming in nature, 4 Mbps will not be achievable a reasonable percentage of the time. For this design, spectrum costs[57] were included because of the significant investment in spectrum required for this design. To be consistent with the first two wireless designs, no spectrum costs were included for the first purchase of 2x6 MHz 700 MHz spectrum, only the cost of the additional spectrum. Including the cost of the first 700 MHz spectrum would add to the total cost of this design.

Although the OBI No. 1 uses microwave backhaul extensively, fiber optic backhaul was assumed for all LTE tower locations in Vantage Point's studies. Microwave backhaul was considered, but due to bandwidth limitations in the proposed areas, long distances for the required links, and lack of spectrum, fiber optic backhaul was determined to be preferable. For the longest routes in the case studies, even equipment operating in the 6 GHz band would be unlikely to achieve the required modulation levels to support the high bandwidth demands of LTE. Furthermore, as shown in Figure 4-2, there are multiple 6

[54] 5 MHz channel with a spectral efficiency of 1.5 bps/Hz.
[55] Id., Exhibit 4-BS and pp. 111-113.
[56] (10 MHz X 1.5 bps/Hz) + (5 MHz X 1.5 bps/Hz) = 22.5 Mbps.
[57] The cost of procuring *additional* 700 MHz spectrum is based on two times the market value of the Auction 73 results and the cost of procuring *additional* AWS spectrum is based on a 26% reduction from two times the market value of the Auction 73 results.

GHz paths in the vicinity of the GPC exchanges, potentially limiting the available spectrum. The OBI No. 1 noted that since "higher data rates require more spectrum" and "there is only a limited amount of spectrum available, carriers can only have a limited number of the high-speed microwave links in a geographic area."[58]

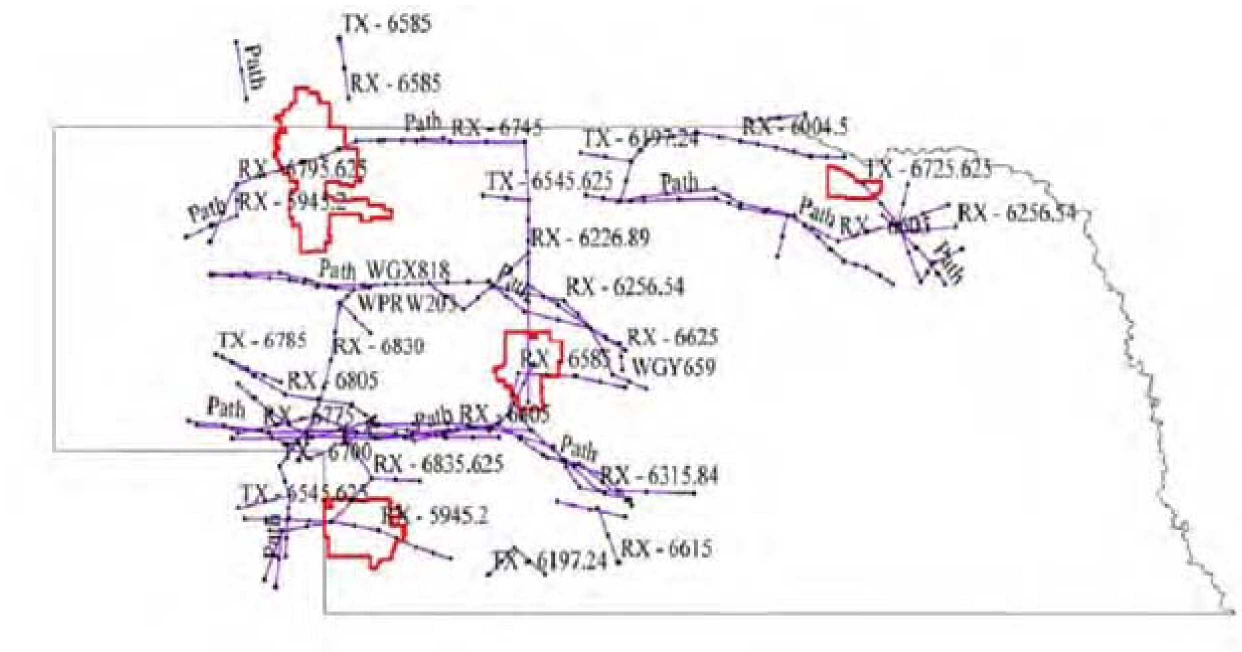


Figure 4-2 Existing 6 GHz Microwave Links

The radio signals from towers other than the one serving a specific customer appear as noise to the customer and make it more difficult to achieve the desired broadband speed. As more broadband speed is demanded, more towers are required, which results in more system noise that degrades network performance. Although the 700 MHz spectrum is well suited for rural applications, unwanted signals from neighboring 700 MHz systems can propagate for 30 or more miles and impair system performance.

[58] OBI No. 1, p. 76.

4.1 Verdigre Exchange Case Study

4.1.1 Existing Conditions

To determine the accuracy of the OBI Broadband Availability Model, the investment requirements determined by the Vantage Point engineering designs were compared to the investment calculated by the OBI Broadband Availability Model. To determine the amount of initial investment calculated by the OBI Broadband Availability Model, it was necessary to use data from the NBP website.[59] The OBI investment was stated on a per county basis, so the county level investment was scaled to the exchange level, by multiplying the total investment in Knox County by the ratio of the exchange area to the county area. Using this method, the OBI DSL investment for the Verdigre exchange is $305,000, as summarized in Table 4-3.

Exchange	Exchange Sq Miles	County	Total County Sq Miles	Exchange Sq Miles in County	OBI DSL Investment for County	OBI DSL Investment Per Sq Mile	OBI Estimate Applied to Exchange Area in County	OBI DSL Total for Exchange
Verdigre	175.8	Knox	1108.1	175.8	$ 1,920,000	$ 1,700	$ 305,000	$ 305,000

Table 4-3: OBI DSL Investment Calculation for Verdigre Exchange

Additionally, using the same methods, the OBI wireless investment of $160,000 for the exchange was calculated, as summarized in Table 4-4.

Exchange	OBI Wireless Investment for County	OBI Wireless Investment Per Sq Mile	OBI Estimate Applied to Exchange Area in County	OBI Wireless Total for Exchange
Verdigre	$ 1,000,000	$ 900	$ 160,000	$ 160,000

Table 4-4: OBI Wireless Investment Calculation for Verdigre Exchange

GPC serves portions of the Verdigre exchange with a twisted pair copper network and portions with a FTTP network. There are 506 customer locations in the exchange. Figure 4-3 shows the Verdigre exchange relative to the other GPC exchanges that were evaluated.

[59] http://www.broadband.gov/plan/deployment-cost-model.html .

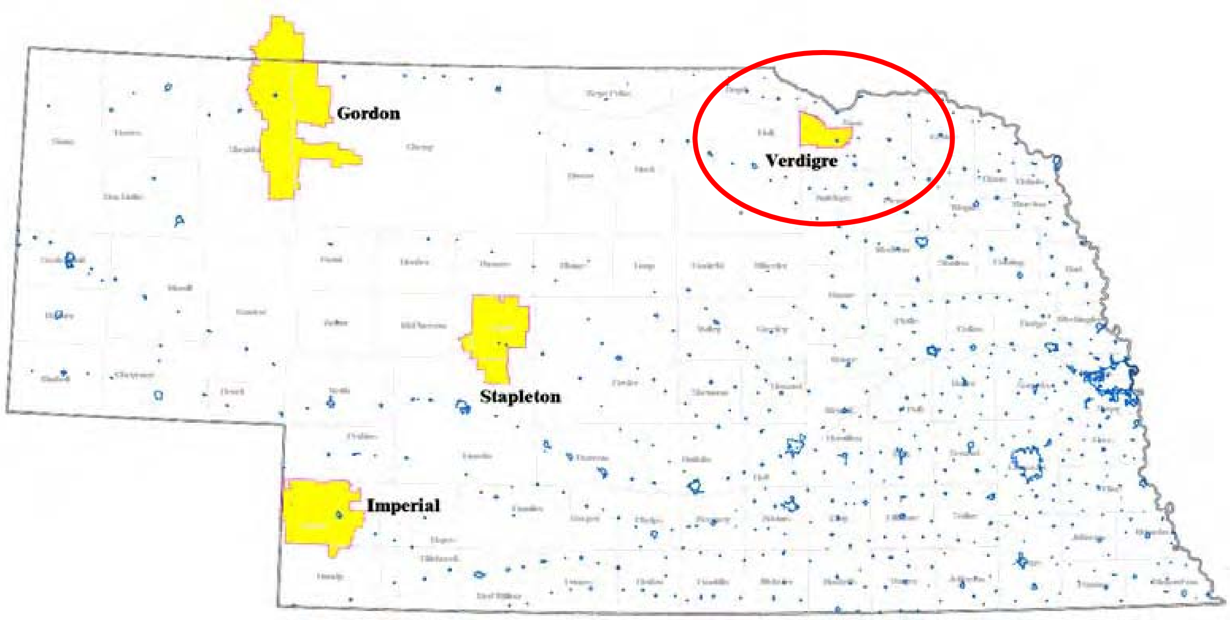


Figure 4-3: Exchange Serving Area Summary

Table 4-5 shows the number of locations that can be served with 4/1 Mbps broadband using the existing infrastructure.

Exchange	Copper Locations (with existing 4/1 Mbps capability)	FTTP Locations (with existing 4/1 Mbps capability)	% of Locations
Verdigre	327	135	91%

Table 4-5: Existing 4 /1 Mbps Capability Summary

4.1.2 Verdigre Wireline Case Studies

4.1.2.1 4 Mbps Design – No Oversubscription

In order to meet the 4/1 Mbps speed target, three digital loop carrier (DLC) cabinets would have to be installed in the Verdigre exchange. These DLCs would decrease the copper distance from the electronics to customer locations currently incapable of broadband, allowing an additional 38 locations to be served by ADSL2+ at 4/1 Mbps. Table 4-6 summarizes the estimated investment costs.

4/1 Mbps Additional Locations	4/1 Mbps Total Locations	4/1 Mbps % Served	4/1 Mbps Electronics Investment	4/1 Mbps OSP Investment	4/1 Mbps Total Investment	4/1 Mbps Investment per Additional Location
38	500	99%	$130,000	$225,000	$355,000	$9,300

Table 4-6: Verdigre Exchange 4/1Mbps Broadband Availability Addition

With the addition of three DLC cabinets, 99% of the locations within the Verdigre exchange would be capable of 4/1 Mbps service.

4.1.2.2 20 Mbps Design – No Oversubscription

The existing FTTP network in rural areas and the short copper distances within town make 86% of the locations in the Verdigre exchange capable of 20 Mbps of bandwidth with only minimal investment as shown in Table 4-7.

20 Mbps Copper Locations	20 Mbps FTTP Locations	20 Mbps Total Locations	20 Mbps % Served
300	135	435	86%

Table 4-7: Verdigre Exchange Existing 20 Mbps Network Capability

To estimate the cost of providing all customers in the exchange with 20 Mbps service, the deployment of FTTP to all rural locations was evaluated. All Verdigre in-town subscribers could continue to be served via the existing twisted-pair copper network, since ADSL2+ has the bandwidth capability to provide 20 Mbps at relatively short distances.

Table 4-8 summarizes the estimated investment costs to reach the all locations in rural Verdigre with 20 Mbps service.

20 Mbps Additional Locations	20 Mbps Total Locations	20 Mbps % Served	20 Mbps Electronics Investment	20 Mbps OSP Investment	20 Mbps Total Investment	20 Mbps Investment per Additional Location
71	506	100%	$165,000	$600,000	$765,000	$10,800

Table 4-8: Verdigre Exchange 20 Mbps Broadband Availability Addition

This network design would result in all locations in the Verdigre exchange having at least 20 Mbps broadband availability. All rural subscribers would have access to bandwidth far in excess of 20 Mbps since they would be served via a FTTP network.

4.1.2.3 100 Mbps Design – No Oversubscription

Customers are expected to demand broadband speeds greater than 100 Mbps within the next five to ten years. Vantage Point therefore designed a network to accommodate the increased demand. Because of the existing FTTP network, GPC can currently deliver 100 Mbps to 135 locations in the exchange, with only minimal investment.

Since copper is generally incapable of supporting broadband speeds of 100 Mbps, Vantage Point investigated the investment required to deploy FTTP to all in-town and rural locations. Table 4-9 summarizes the estimated investment costs to reach all locations with 100 Mbps broadband.

100 Mbps Additional Locations	100 Mbps Total Locations	100 Mbps % Served	100 Mbps Electronics Investment	100 Mbps OSP Investment	100 Mbps Total Investment	100 Mbps Investment per Additional Location
371	506	100%	$415,000	$1,665,000	$2,080,000	$5,600

Table 4-9: Verdigre Exchange 100 Mbps Broadband Availability Addition

The additional investment to deploy FTTP to all customers is approximately $5,600 per additional location.

4.1.3 Verdigre Wireless Case Studies

4.1.3.1 4 Mbps Design – 25:1 Oversubscription

In this section, the 4/1 Mbps broadband service design assumes a BHOL of 160 kbps per subscriber. This BHOL assumption results in an oversubscription ratio of 25:1. Utilizing the spectral efficiency and obtainable spectrum assumptions previously mentioned and assuming a BHOL of 160 kbps results in the network constraint of 46 subscribers per sector, as shown in Equation 4-1.

$$\frac{(5\ MHz) * \left({}^{1.5\ bps}/_{Hz} \Big/ {}_{Sector} \right)}{\left({}^{160\ kbps}/_{subscriber} \right)} = 46.875$$

$$\equiv 46\ \text{subscribers/sector}$$

Equation 4-1: 160 kbps BHOL Subscribers

For broadband to be made available over an LTE network with 25:1 oversubscription, a single collocation trisector LTE site would be necessary. This site would provide an additional 44 locations with capability of 4 Mbps, presuming that the OBI's 160 kbps BHOL assumption is adequate.

Table 4-10 summarizes the estimated investment costs to reach the unserved locations.

4/1 Mbps Additional Locations	4/1 Mbps Total Locations	4/1 Mbps % Served	4/1 Mbps Core Network Electronics Investment	4/1 Mbps RAN Electronics Investment	4/1 Mbps CPE Investment	4/1 Mbps Total Investment	4/1 Mbps Investment per Additional Location
44	506	100%	$8,000	$265,000	$30,000	$303,000	$6,900

Table 4-10: Verdigre Exchange 4 Mbps at 160 kbps BHOL Broadband Availability Addition

The addition of one LTE site would expand the availability of 4 Mbps broadband to nearly all of the locations within the exchange area. Although theoretically this wireless design could cover all locations, in reality a few customers would likely remain unserved. Measurements would need to be taken to verify the actual coverage of the design. All the wireless designs presented in the Vantage Point case studies share this shortcoming.

4.1.3.2 4 Mbps Design – 9:1 Oversubscription

In this section, the 4/1 Mbps broadband service design will have a BHOL assumption of 444 kbps per subscriber, which results in an oversubscription ratio of 9:1. In a 4 Mbps wireless network with 9:1 oversubscription, each sector can serve 16 subscribers, as shown in the following equation.

$$\frac{(5\ MHz) * \left({}^{1.5\ bps/_{Hz}}/_{Sector} \right)}{\left({}^{444\ kbps}/_{subscriber} \right)} = 16.892$$

$$\equiv 16\ \text{subscribers/sector}$$

Equation 4-2: 444 kbps BHOL Subscribers

Since there are 44 customers without 4/1 Mbps availability and only 16 subscribers can be served per sector, two collocation trisector LTE sites will need to be deployed. Table 4-11 summarizes the estimated investment costs.

4/1 Mbps Additional Locations	4/1 Mbps Total Locations	4/1 Mbps % Served	4/1 Mbps Core Network Electronics Investment	4/1 Mbps RAN Electronics Investment	4/1 Mbps CPE Investment	4/1 Mbps Total Investment	4/1 Mbps Investment per Additional Location
44	506	100%	$8,000	$525,000	$30,000	$563,000	$12,800

Table 4-11: Verdigre Exchange 4 Mbps at 444kbps BHOL Broadband Availability Addition

The addition of two trisector LTE sites would increase the availability of 4 Mbps broadband to all of the locations within the exchange area at a cost of $12,800 per additional location.

4.1.3.3 4 Mbps Design – 9:1 Oversubscription with Additional Spectrum

Vantage Point also designed a network assuming a BHOL of 444 kbps and two additional 2x5 MHz of spectrum, one of which would be adjacent to the spectrum already available. This network can support 49 subscribers per sector, as shown in the following equation:

$$\frac{(10\ MHz) * \left({}^{1.5\ bps}/_{Hz} \Big/_{Sector} \right)}{\left({}^{444\ kbps}/_{subscriber} \right)} + \frac{(5\ MHz) * \left({}^{1.5\ bps}/_{Hz} \Big/_{Sector} \right)}{\left({}^{444\ kbps}/_{subscriber} \right)}$$

$$= 33.784 + 16.892$$

$$\equiv 33 + 16 = \ 49\ \text{subscribers/sector}$$

Equation 4-3: 444 kbps BHOL Subscribers

For this scenario, the deployment of a single trisector LTE site was required. The addition of a collocation trisector LTE site would provide 4 Mbps broadband service to an additional 44 households.

Table 4-12 summarizes the estimated investment.

4/1 Mbps Additional Locations	4/1 Mbps Total Locations	4/1 Mbps % Served	4/1 Mbps Core Network Electronics and Additional Spectrum Investment	4/1 Mbps RAN Electronics Investment	4/1 Mbps CPE Investment	4/1 Mbps Total Investment	4/1 Mbps Investment per Additional Location
44	506	100%	$11,285,000	$340,000	$30,000	$11,655,000	$264,900

Table 4-12: Verdigre Exchange 4 Mbps at 444kbps BHOL Broadband Availability Addition

The addition of one trisector LTE site and the procurement of two additional 2 x 5 MHz of spectrum would increase the availability of 4 Mbps broadband to all of the locations within the exchange area at a cost of approximately $265,000 per additional location.

4.2 Stapleton Exchange Case Study

For this case study, wireline and wireless designs were evaluated to increase the broadband availability in GPC's Stapleton exchange in west central Nebraska, a very sparsely populated part of the state. Extrapolating OBI DSL countywide estimates to the Stapleton exchange shows that the OBI estimates approximately $580,000 will be required to provide 4 Mbps DSL service in the exchange. The Stapleton exchange is located primarily in Logan County, but covers portions of Lincoln and McPherson Counties as well. Table 4-13 is a summary of the calculation.

Exchange	Exchange Sq Miles	County	Total County Sq Miles	Exchange Sq Miles in County	OBI DSL Investment for County	OBI DSL Investment Per Sq Mile	OBI Estimate Applied to Exchange Area in County	OBI Total for Exchange
Stapleton	574.0	Logan	570.7	455.8	$ -	$ -	$ -	$ 580,000
		McPherson	859.0	22.4	$ 3,240,000	$ 3,800	$ 85,000	
		Lincoln	2564.0	95.8	$ 13,260,000	$ 5,200	$ 495,000	

Table 4-13: OBI DSL Investment Calculation for Stapleton Exchange

Additionally, the OBI wireless investment of $235,000 for the exchange was calculated, as summarized in Table 4-14.

Exchange	County	OBI Wireless Investment for County	OBI Wireless Investment Per Sq Mile	OBI Estimate Applied to Exchange Area in County	OBI Total for Exchange
Stapleton	Logan	$ -	$ -	$ -	$ 235,000
	McPherson	$ 2,825,000	$ 3,300	$ 75,000	
	Lincoln	$ 4,230,000	$ 1,700	$ 160,000	

Table 4-14: OBI Wireless Investment Calculation for Stapleton Exchange

4.2.1 Existing Conditions

GPC serves 507 customer locations in the Stapleton exchange with a twisted pair copper network. With the existing outside plant, GPC has the capability to serve 228 locations, or 45% of the locations, with 4/1 Mbps broadband.

Figure 4-4 shows the area covered by the Stapleton exchange and its relationship to the other GPC case study exchanges.

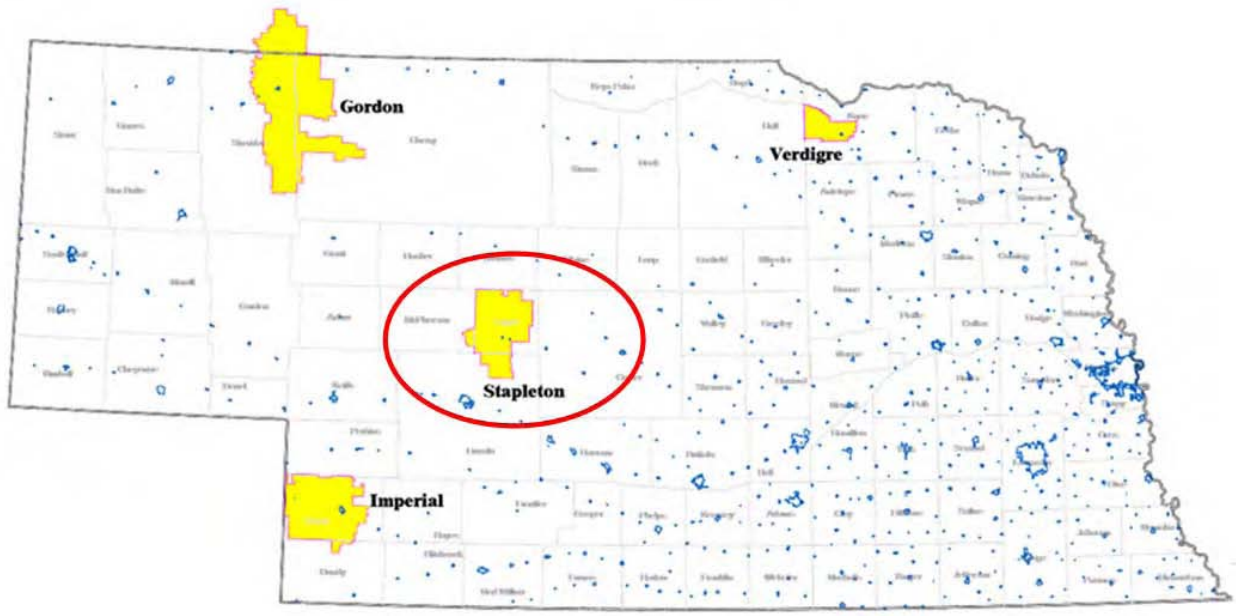


Figure 4-4: Exchange Serving Area Summary

4.2.2 Stapleton Wireline Case Studies

4.2.2.1 4 Mbps Design – No Oversubscription

Twenty-seven new DLCs would need to be deployed in the Stapleton exchange, so that an additional 266 customer locations would be able to receive 4/1 Mbps broadband utilizing ADSL2+ technology.

Table 4-15 summarizes the estimated investment costs.

4/1 Mbps Additional Locations	4/1 Mbps Total Locations	4/1 Mbps % Served	4/1 Mbps Electronics Investment	4/1 Mbps OSP Investment	4/1 Mbps Total Investment	4/1 Mbps Investment per Additional Location
266	494	97%	$385,000	$1,635,000	$2,020,000	$7,600

Table 4-15: Stapleton Exchange 4/1 Mbps Broadband Speed Availability Addition

As shown, the addition of these remote DLC cabinets would expand the availability of 4/1 Mbps broadband speeds to 97% of locations within the exchange area.

4.2.2.2 20 Mbps Design – No Oversubscription

Due to the short copper distances within the Stapleton town service area, all town subscribers could receive 20 Mbps service using the existing twisted-pair copper network and ADSL2+ technology. Thus, GPC has existing capability to serve 40% of the locations in the exchange with 20 Mbps of bandwidth with minimal investment, as is demonstrated in Table 4-16.

20 Mbps Copper Locations	20 Mbps FTTH Locations	20 Mbps Total Locations	20 Mbps % Served
204	0	204	40%

Table 4-16: Stapleton Exchange Existing 20 Mbps Network Capability

To increase the bandwidth capabilities to provide all locations in the exchange with 20 Mbps, construction of FTTP to all the rural locations in the exchange was evaluated.

Table 4-17 summarizes the estimated investment costs.

20 Mbps Additional Locations	20 Mbps Total Locations	20 Mbps % Served	20 Mbps Electronics Investment	20 Mbps OSP Investment	20 Mbps Total Investment	20 Mbps Investment per Additional Location
303	507	100%	$530,000	$3,255,000	$3,785,000	$12,500

Table 4-17: Stapleton Exchange 20 Mbps Broadband Availability Addition

All rural subscribers would have access to bandwidth far in excess of 20 Mbps since they would be served by FTTP. As displayed above, the additional investment per currently unserved location is approximately $12,500.

4.2.2.3 100 Mbps Design – No Oversubscription

A final wireline design estimated the investment required to provide all Stapleton customers with 100 Mbps service. The investment necessary to deploy FTTP to all customer locations was calculated. Table 4-18 summarizes this investment.

100 Mbps Additional Locations	100 Mbps Total Locations	100 Mbps % Served	100 Mbps Electronics Investment	100 Mbps OSP Investment	100 Mbps Total Investment	100 Mbps Investment per Additional Location
507	507	100%	$675,000	$4,075,000	$4,750,000	$9,400

Table 4-18: Stapleton Exchange 100 Mbps Broadband Availability Addition

The additional investment is approximately $9,400 per location.

4.2.3 Stapleton Wireless Case Studies

4.2.3.1 4 Mbps Design – 25:1 Oversubscription

As described in Section 4.1.3.1, this scenario has a BHOL assumption of 160 kbps. Assuming the same spectral efficiencies as before, a sector could serve 46 subscribers. The deployment of three trisector LTE sites was, therefore, deemed necessary to provide 4/1 Mbps. The addition of one collocation trisector LTE site and two new trisector LTE sites would extend 4 Mbps capacity to an additional 279 households. The estimated investment costs are shown in Table 4-19 below.

4/1 Mbps Additional Locations	4/1 Mbps Total Locations	4/1 Mbps % Served	4/1 Mbps Core Network Electronics Investment	4/1 Mbps RAN Electronics Investment	4/1 Mbps CPE Investment	4/1 Mbps Total Investment	4/1 Mbps Investment per Additional Location
279	507	100%	$50,000	$1,505,000	$195,000	$1,750,000	$6,300

Table 4-19: Stapleton Exchange 4 Mbps at 160 kbps BHOL Broadband Availability Addition

With 25:1 oversubscription, the addition of three LTE sites would increase the availability of 4 Mbps broadband to all of the locations within the exchange area.

4.2.3.2 4 Mbps Design – 9:1 Oversubscription

Using the assumptions of the 9:1 oversubscription scenario, a sector could serve 16 subscribers. For 4 Mbps broadband to be provided on an LTE network designed for a BHOL of 444 kbps, one collocation trisector LTE site and six new trisector LTE sites must be deployed. These sites would provide 4 Mbps broadband service to an additional 279 households. Table 4-20 shows the estimated investment costs associated LTE.

4/1 Mbps Additional Locations	4/1 Mbps Total Locations	4/1 Mbps % Served	4/1 Mbps Core Network Electronics Investment	4/1 Mbps RAN Electronics Investment	4/1 Mbps CPE Investment	4/1 Mbps Total Investment	4/1 Mbps Investment per Additional Location
279	507	100%	$50,000	$2,865,000	$195,000	$3,110,000	$11,100

Table 4-20: Stapleton Exchange 4 Mbps at 444 kbps BHOL Broadband Availability Addition

The deployment of seven trisector LTE sites would expand the availability of 4 Mbps broadband to all locations within the Stapleton exchange.

4.2.3.3 4 Mbps Design – 9:1 Oversubscription with Additional Spectrum

As described in Section 4.1.3.3, this scenario has a BHOL assumption of 444 kbps per subscriber. Assuming the same quantity of spectrum can be procured and the same spectral efficiencies as before, a sector could serve 49 subscribers. Therefore, the addition of one collocation trisector LTE site and two new trisector LTE sites would provide 4 Mbps broadband service to an additional 279 households. Table 4-21 summarizes the estimated investment under this scenario.

4/1 Mbps Additional Locations	4/1 Mbps Total Locations	4/1 Mbps % Served	4/1 Mbps Core Network Electronics and Additional Spectrum Investment	4/1 Mbps RAN Electronics Investment	4/1 Mbps CPE Investment	4/1 Mbps Total Investment	4/1 Mbps Investment per Additional Location
279	507	100%	$2,915,000	$1,785,000	$195,000	$4,895,000	$17,500

Table 4-21: Stapleton Exchange 4 Mbps at 444 kbps BHOL Broadband Availability Addition

The addition of three trisector LTE sites and the procurement of two additional 2 x 5 MHz of spectrum would increase the availability of 4 Mbps broadband to all locations within the exchange area.

4.3 Imperial Exchange Case Study

For this case study, wireline and wireless designs were evaluated to increase the broadband availability in GPC's Imperial exchange in southwest Nebraska. The OBI DSL investment estimate for the exchange, $3,535,000, is used for comparison. Table 4-22 is a summary of the OBI investment for the Imperial exchange, which is located in Chase and Dundy Counties.

Exchange	Exchange Sq Miles	County	Total County Sq Miles	Exchange Sq Miles in County	OBI DSL Investment for County	OBI DSL Investment Per Sq Mile	OBI Estimate Applied to Exchange Area in County	OBI Total for Exchange
Imperial	685.0	Dundy	919.9	21.3	$ 4,785,000	$ 5,200	$ 110,000	$ 3,535,000
		Chase	894.5	663.7	$ 4,615,000	$ 5,200	$ 3,425,000	

Table 4-22: OBI DSL Investment Calculation for Imperial Exchange

Additionally, the OBI wireless investment of $1,385,000 for the exchange was calculated, as summarized in Table 4-23.

Exchange	County	OBI Wireless Investment for County	OBI Wireless Investment Per Sq Mile	OBI Estimate Applied to Exchange Area in County	OBI Total for Exchange
Imperial	Dundy	$ 2,210,000	$ 2,400	$ 50,000	$ 1,385,000
	Chase	$ 1,800,000	$ 2,000	$ 1,335,000	

Table 4-23: OBI Wireless Investment Calculation for Imperial Exchange

4.3.1 Existing Conditions

With its existing outside plant network, GPC has the capability to provide 1,271 of the 2,099 locations, or 61%, with 4/1 Mbps service. Figure 4-5 shows the area covered by the Imperial exchange and its relationship to the other GPC exchanges that were evaluated as separate case studies.

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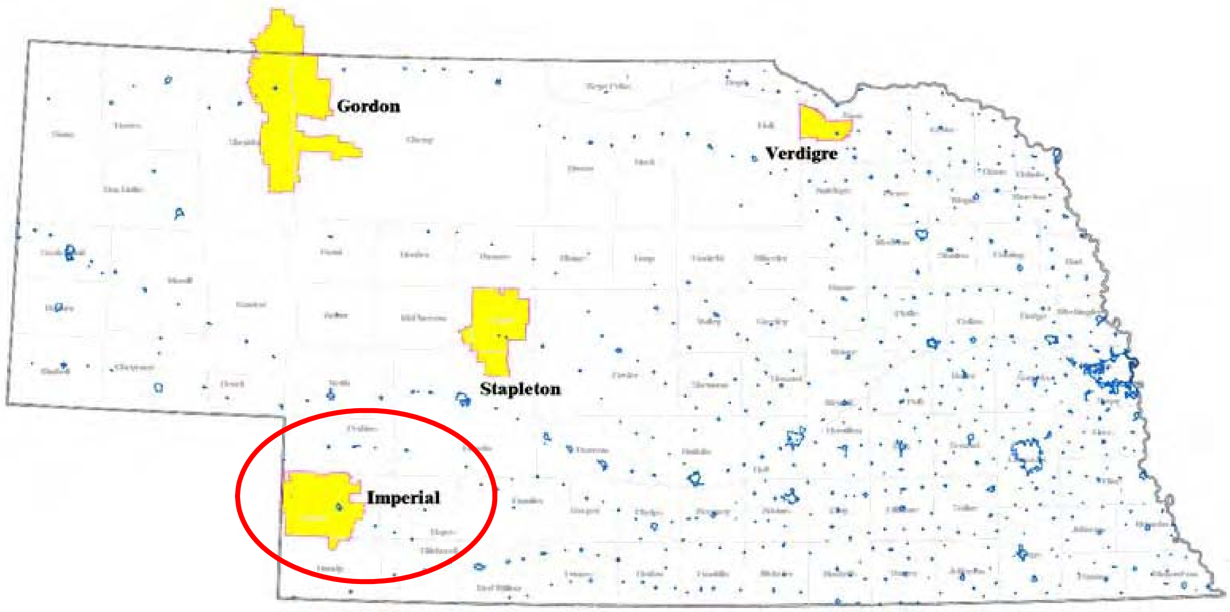


Figure 4-5: Exchange Serving Area Summary

4.3.2 Imperial Wireline Case Studies

4.3.2.1 4 Mbps Design – No Oversubscription

To increase the availability of 4/1 Mbps broadband speeds, the deployment of 44 additional remote DLC cabinets would be necessary. By deploying the additional DLCs, GPC would be able to decrease the copper distance from the electronics to 813 currently unserved customer locations, allowing for at least 4/1 Mbps capability, using ADSL2+ technology. Table 4-24 summarizes the estimated investment required.

4/1 Mbps Additional Locations	4/1 Mbps Total Locations	4/1 Mbps % Served	4/1 Mbps Electronics Investment	4/1 Mbps OSP Investment	4/1 Mbps Total Investment	4/1 Mbps Investment per Additional Location
813	2084	99%	$770,000	$1,635,000	$2,405,000	$3,000

Table 4-24: Imperial Exchange 4/1 Mbps Broadband Speed Availability Addition

As shown, the addition of these 44 DLCs would increase the availability of 4/1 Mbps broadband speed to 99% of the locations within the exchange area.

4.3.2.2 20 Mbps Design – No Oversubscription

GPC has existing capability to provide 60% of the locations with 20 Mbps service with minimal investment as shown in Table 4-25.

20 Mbps Copper Locations	20 Mbps FTTH Locations	20 Mbps Total Locations	20 Mbps % Served
1251	0	1251	60%

Table 4-25: Imperial Exchange Existing 20 Mbps Network Capability

To increase the bandwidth capabilities to provide all locations in the exchange with 20 Mbps, construction of FTTP to all the rural locations was evaluated. In this design scenario, all town subscribers would continue to be served on the existing twisted-pair copper network utilizing ADSL2+. Table 4-26 summarizes the investment required.

20 Mbps Additional Locations	20 Mbps Total Locations	20 Mbps % Served	20 Mbps Electronics Investment	20 Mbps OSP Investment	20 Mbps Total Investment	20 Mbps Investment per Additional Location
848	2099	100%	$1,350,000	$5,385,000	$6,735,000	$8,000

Table 4-26: Imperial Exchange 20 Mbps Broadband Availability Addition

As shown, this design would result in all locations in the Imperial exchange having 20 Mbps broadband availability, with an investment of $8,000 per additional location. Rural subscribers would have access to bandwidth far in excess of 20 Mbps since they would be served via a FTTP network.

4.3.2.3 100 Mbps Design – No Oversubscription

To increase the bandwidth capacity of all locations to 100 Mbps, the investment required to deploy FTTP in the town and rural serving areas of Imperial was determined, GPC has no existing 100 Mbps capability in the Imperial exchange. Table 4-27 summarizes the estimated investment required.

100 Mbps Additional Locations	100 Mbps Total Locations	100 Mbps % Served	100 Mbps Electronics Investment	100 Mbps OSP Investment	100 Mbps Total Investment	100 Mbps Investment per Additional Location
2099	2099	100%	$2,410,000	$10,150,000	$12,560,000	$6,000

Table 4-27: Imperial Exchange 100 Mbps Broadband Availability Addition

An additional investment of approximately $6,000 per location is required to provide all residents of the Imperial exchange with 100 Mbps capability.

4.3.3 Imperial Wireless Case Studies

4.3.3.1 4 Mbps Design – 25:1 Oversubscription

As described in Section 4.1.3.1, under this scenario, a sector could serve 46 subscribers. In order to provide 4 Mbps broadband service to 828 currently unserved customer locations, one trisector collocated LTE site and six new trisector LTE sites would be required. Table 4-28 summarizes the number of locations and the estimated investment costs to provide 4 Mbps broadband speeds under this scenario.

4/1 Mbps Additional Locations	4/1 Mbps Total Locations	4/1 Mbps % Served	4/1 Mbps Core Network Electronics Investment	4/1 Mbps RAN Electronics Investment	4/1 Mbps CPE Investment	4/1 Mbps Total Investment	4/1 Mbps Investment per Additional Location
828	2099	100%	$140,000	$3,005,000	$580,000	$3,725,000	$4,500

Table 4-28: Imperial Exchange 4 Mbps at 160 kbps BHOL Broadband Availability Addition

The addition of seven LTE sites would increase the availability of 4 Mbps broadband to all locations within the exchange area at a cost of $4,500 per additional location.

4.3.3.2 4 Mbps Design – 9:1 Oversubscription

With 9:1 oversubscription, a sector could serve 16 subscribers, as is described in Section 4.1.3.2. The deployment of one collocation trisector LTE site and nineteen new trisector LTE sites would be needed to provide ubiquitous 4 Mbps broadband service. Table 4-29 summarizes the estimated investment required.

4/1 Mbps Additional Locations	4/1 Mbps Total Locations	4/1 Mbps % Served	4/1 Mbps Core Network Electronics Investment	4/1 Mbps RAN Electronics Investment	4/1 Mbps CPE Investment	4/1 Mbps Total Investment	4/1 Mbps Investment per Additional Location
828	2099	100%	$140,000	$8,410,000	$580,000	$9,130,000	$11,000

Table 4-29: Imperial Exchange 4 Mbps at 444 kbps BHOL Broadband Availability Addition

The addition of 20 trisector LTE sites would increase the availability of 4 Mbps broadband to all locations within the Imperial exchange area at a cost of $11,000 per currently unserved location.

4.3.3.3 4 Mbps Design – 9:1 Oversubscription with Additional Spectrum

Using the same assumptions as described in Section 4.1.3.3, this scenario has a BHOL assumption of 444 kbps per subscriber. Assuming the same quantity of spectrum can be procured and the same spectral efficiencies as before, a sector could serve 49 subscribers.

In order to increase the availability of 4 Mbps broadband service to the unserved households utilizing a LTE network at the 444 kbps BHOL, the deployment of seven trisector LTE sites was determined to be necessary. The addition of one collocation trisector LTE site and six new trisector LTE sites would provide 4 Mbps broadband service to an additional 828 households. Table 4-30 summarizes estimated investment costs for this LTE deployment.

4/1 Mbps Additional Locations	4/1 Mbps Total Locations	4/1 Mbps % Served	4/1 Mbps Core Network Electronics and Additional Spectrum Investment	4/1 Mbps RAN Electronics Investment	4/1 Mbps CPE Investment	4/1 Mbps Total Investment	4/1 Mbps Investment per Additional Location
828	2099	100%	$3,600,000	$3,525,000	$580,000	$7,705,000	$9,300

Table 4-30: Imperial Exchange 4 Mbps at 444 kbps BHOL Broadband Availability Addition

At a cost of $9,300 per currently unserved customer the addition of seven trisector LTE sites and the procurement of two additional 2 x 5 MHz of spectrum would increase the availability of 4 Mbps broadband to all locations within the Imperial exchange.

4.4 Gordon Exchange Case Study

For this case study, wireline and wireless designs were evaluated to increase the broadband availability in GPC's Gordon exchange, which serves portions of the Nebraska counties of Cherry and Sheridan and a small portion of the South Dakota county of Shannon.

The calculated OBI DSL investment, $4,845,000, is summarized in Table 4-31 below.

Exchange	Exchange Sq Miles	County	Total County Sq Miles	Exchange Sq Miles in County	OBI DSL Investment for County	OBI DSL Investment Per Sq Mile	OBI Estimate Applied to Exchange Area in County	OBI Total for Exchange
Gordon	1378.8	Sheridan	2441.0	666.6	$ 7,215,000	$ 3,000	$ 1,970,000	$ 4,845,000
		Cherry	5960.5	485.9	$ 22,675,000	$ 3,800	$ 1,850,000	
		Shannon (SD)	2097.0	226.3	$ 9,515,000	$ 4,500	$ 1,025,000	

Table 4-31: OBI DSL Investment Calculation for Gordon Exchange

Additionally, the OBI wireless investment of $2,645,000 for the exchange was calculated, as summarized in Table 4-32.

Exchange	County	OBI Wireless Investment for County	OBI Wireless Investment Per Sq Mile	OBI Estimate Applied to Exchange Area in County	OBI Total for Exchange
Gordon	Sheridan	$ 3,925,000	$ 1,600	$ 1,070,000	$ 2,645,000
	Cherry	$ 14,855,000	$ 2,500	$ 1,210,000	
	Shannon (SD)	$ 3,375,000	$ 1,600	$ 365,000	

Table 4-32: OBI Wireless Investment Calculation for Gordon Exchange

4.4.1 Existing Conditions

In the Gordon exchange, GPC serves 1,962 locations with a twisted pair copper network. The existing outside plant infrastructure has similar capabilities and characteristics to the plant described in the initial case study in Section 4.1. With this existing outside plant network architecture, GPC has the capability to serve 56% of the locations, or 1,096 locations, with 4/1 Mbps broadband. Figure 4-6 shows the Gordon exchange and its relationship to other GPC case study exchanges. The Gordon exchange provides service to a particularly sparsely populated area. The house densities of Sheridan, Cherry and Shannon counties are 1.2, 0.5 and 1.5 housing units per square mile, respectively.

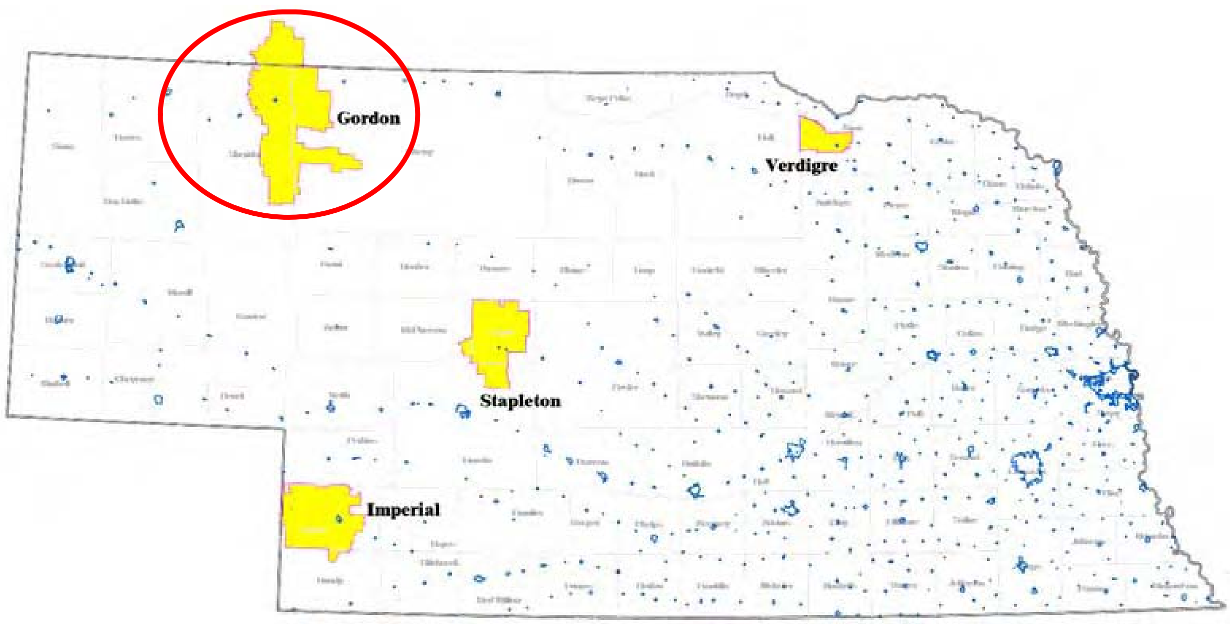


Figure 4-6: Exchange Serving Area Summary

4.4.2 Gordon Wireline Case Studies

4.4.2.1 4 Mbps Design – No Oversubscription

To increase the availability of 4/1 Mbps broadband speeds, the deployment of 99 additional DLCs was determined to be necessary. By deploying these additional DLCs, GPC would be able to decrease copper distances to under 14,000 feet and provide 4 Mbps broadband service to an additional 843 locations. Table 4-33 summarizes the estimated investment required.

4/1 Mbps Additional Locations	4/1 Mbps Total Locations	4/1 Mbps % Served	4/1 Mbps Electronics Investment	4/1 Mbps OSP Investment	4/1 Mbps Total Investment	4/1 Mbps Investment per Additional Location
843	1939	99%	$1,295,000	$6,285,000	$7,580,000	$9,000

Table 4-33: Gordon Exchange 4 Mbps Broadband Availability Addition

This upgrade would result in 99% of the customer locations having the capability of 4/1 Mbps.

4.4.2.2 20 Mbps Design – No Oversubscription

Due to the short copper distances in the town of Gordon, GPC can serve 52% of the town locations with 20 Mbps bandwidth by making a minimal investment, as shown in Table 4-34.

20 Mbps Copper Locations	20 Mbps FTTH Locations	20 Mbps Total Locations	20 Mbps % Served
1018	0	1018	52%

Table 4-34: Gordon Exchange Existing 20 Mbps Network Capability

To increase the bandwidth capabilities to provide all locations in the exchange with 20 Mbps, construction of FTTP to all rural locations would be needed. The estimated investment for a FTTP deployment is shown in Table 4-35 .

20 Mbps Additional Locations	20 Mbps Total Locations	20 Mbps % Served	20 Mbps Electronics Investment	20 Mbps OSP Investment	20 Mbps Total Investment	20 Mbps Investment per Additional Location
944	1962	100%	$1,695,000	$8,145,000	$9,840,000	$10,400

Table 4-35: Gordon Exchange 20 Mbps Broadband Availability Addition

With this design, all locations in the Gordon exchange would have 20 Mbps broadband availability and all rural subscribers would have access to bandwidth far in excess of 20 Mbps. The additional investment is approximately $10,400 for each location currently unserved with 20 Mbps capability.

4.4.2.3 100 Mbps Design – No Oversubscription

Vantage Point also designed a 100 Mbps network for the Gordon exchange. This design requires the deployment of FTTP to all customers. Table 4-36 summarizes the estimated investment costs.

100 Mbps Additional Locations	100 Mbps Total Locations	100 Mbps % Served	100 Mbps Electronics Investment	100 Mbps OSP Investment	100 Mbps Total Investment	100 Mbps Investment per Additional Location
1962	1962	100%	$2,525,000	$11,450,000	$13,975,000	$7,100

Table 4-36: Gordon Exchange 100 Mbps Broadband Availability Addition

Vantage Point concludes that all customers in the Gordon exchange could receive 100 Mbps broadband availability with an additional investment of $7,100 per location.

4.4.3 Gordon Wireless Case Studies

4.4.3.1 4 Mbps Design – 25:1 Oversubscription

Since in a 4 Mbps LTE design with 25:1 oversubscription, each sector can serve 46 subscribers, the deployment of three collocation trisector LTE sites and five new trisector LTE sites will be necessary to provide all 866 households with 4 Mbps service.

Table 4-37 displays the estimated investment costs.

4/1 Mbps Additional Locations	4/1 Mbps Total Locations	4/1 Mbps % Served	4/1 Mbps Core Network Electronics Investment	4/1 Mbps RAN Electronics Investment	4/1 Mbps CPE Investment	4/1 Mbps Total Investment	4/1 Mbps Investment per Additional Location
866	1962	100%	$145,000	$4,490,000	$605,000	$5,240,000	$6,000

Table 4-37: Gordon Exchange 4 Mbps at 160 kbps BHOL Broadband Availability Addition

4.4.3.2 4 Mbps Design – 9:1 Oversubscription

As described in Section 4.1.3.2, a 4 Mbps LTE network with 9:1 oversubscription can serve 16 subscribers per sector. Therefore, nineteen new trisector LTE sites must be installed in order to provide 4 Mbps service to all of Gordon's 868 currently unserved households.

The estimated investment costs are shown in Table 4-38.

4/1 Mbps Additional Locations	4/1 Mbps Total Locations	4M/1M % Served	4/1 Mbps Core Network Electronics Investment	4/1 Mbps RAN Electronics Investment	4/1 Mbps CPE Investment	4/1 Mbps Total Investment	4/1 Mbps Investment per Additional Location
866	1962	100%	$145,000	$10,095,000	$605,000	$10,845,000	$12,500

Table 4-38: Gordon Exchange 4 Mbps at 444 kbps BHOL Broadband Availability Addition

With an investment of $12,500 per currently unserved location, this design could extend 4 Mbps broadband to all customers within the Gordon exchange.

4.4.3.3 4 Mbps Design – 9:1 Oversubscription with Additional Spectrum

As described in Section 4.1.3.3, each sector for this LTE design can serve 49 subscribers. Since there are 868 currently unserved households, three collocation trisector LTE sites and five new trisector LTE sites would be required to provide 4 Mbps service.

Table 4-39 summarizes the estimated investment costs.

4/1 Mbps Additional Locations	4/1 Mbps Total Locations	4/1 Mbps % Served	4/1 Mbps Core Network Electronics and Additional Spectrum Investment	4/1 Mbps RAN Electronics Investment	4/1 Mbps CPE Investment	4/1 Mbps Total Investment	4/1 Mbps Investment per Additional Location
866	1962	100%	$4,183,302	$5,064,577	$606,200	$9,854,079	$11,379

Table 4-39: Gordon Exchange 4 Mbps at 444 kbps BHOL Broadband Availability Addition

The addition of eight trisector LTE sites and the procurement of two additional 2 x 5 MHz of spectrum would increase the availability of 4 Mbps broadband to all locations within the Gordon exchange with an investment of approximately $11,400 per additional location.

5 Consolidated Companies Case Study – Design of a Wireline Network

Vantage Point worked with Consolidated Companies (Consolidated) to evaluate its network based upon the 4/1 Mbps requirements proposed in the National Broadband Plan. Consolidated is a Local Exchange Carrier (LEC) that serves 5,561 access lines in central and western Nebraska. The Consolidated service area is large and sparsely populated. In total, Consolidated's service territory covers about 8,900 square miles, an area slightly larger than the state of New Jersey. Consolidated's service area is shown in Figure 5-1.

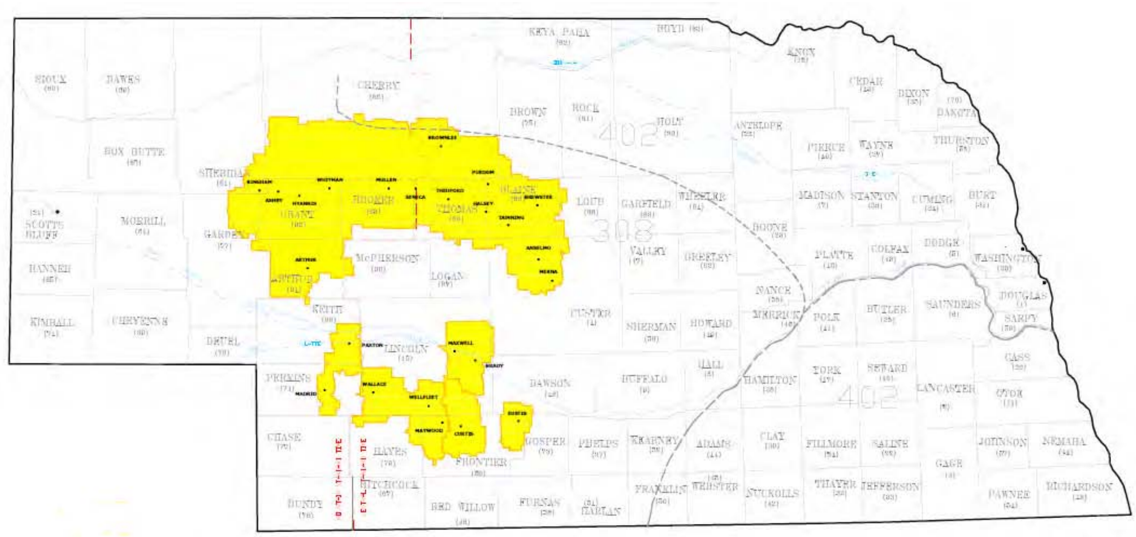


Figure 5-1: Consolidated Companies Exchange Areas

Vantage Point first calculated the percentage of customers that already have broadband capability in excess of 4/1 Mbps, and then determined the upgrade costs associated with providing currently unserved customers with broadband.

5.1 Existing Network Overview

Vantage Point estimates that 4/1 Mbps broadband service can be provided to customers as far as 16,000 cable feet from the central office or field electronics. The copper cable in Consolidated's network is primarily 22 gauge (AWG), and there will be a small percentage of interferers in the cable due to the low population density. Since cables are rarely routed to the customer in a straight line, it is conservatively assumed that all customers within a 12,000 foot radius around central offices or DLCs will be able to able to achieve 4/1 Mbps service.[60]

[60] These assumptions have been verified by Consolidated's deployment of DSL services in similar areas already served by high bandwidth DLC facilities.

Vantage Point then determined the number of locations within a 16,000 foot radius of central offices or DLCs equipped with ADSL2+ capable DSLAMs. Customers currently on a FTTP network were also identified, since they are served by plant capable of far greater speeds than 4/1 Mbps speeds. Of the 5,561 subscribers that Consolidated serves, 4,209 or 76% can currently receive 4/1 Mbps broadband speed. Figure 5-2 represents the currently served area.

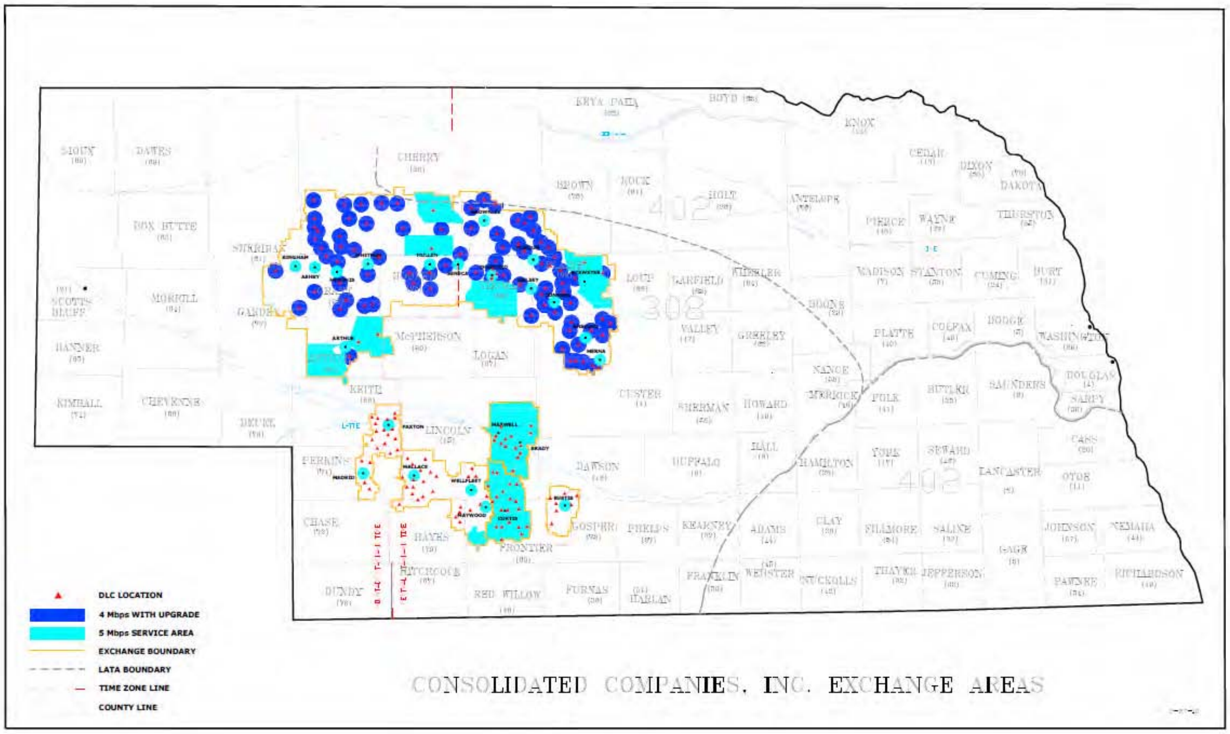


Figure 5-2: Consolidated Companies Broadband Overview

A key factor preventing Consolidated from providing 4 Mbps service is the cost of the middle mile connection. While middle mile costs were not included in Vantage Point's analysis, they are a significant contributor to a carrier's broadband cost. Consolidated purchases backbone from three different carriers and each month pays between $121 and $177 per Mbps. In Omaha, the largest city in Nebraska, carriers pay a mere $10 to $20 per Mbps. Clearly, remotely located rural carriers, such as Consolidated, are affected disproportionately by middle mile and backbone costs. Although these costs are decreasing with time, the rates charged to Consolidated are largely representative of those paid by rural LECs in 2009. Thus, while the OBI model assumes that additional capital expenditures[61] will resolve the availability gap, in many cases high operating expenses, such as middle mile and backbone costs, are preventing rural wireline carriers from providing service at the 4/1 Mbps level.

[61] Such expenditures include build-outs and equipment upgrades.

5.2 4 Mbps Broadband Upgrade Summary

Vantage Point evaluated the cost of providing 4/1 Mbps broadband services to locations not currently served. For this analysis, Vantage Point studied the northern half of Consolidated's service territory. In its northern service area, Consolidated has already deployed over eighty DLCs capable of delivering speeds in excess of 4/1 Mbps if the electronics were upgraded. The existing DLCs are represented by red triangles in Figure 5-3. The backhaul facilities to these remotes are primarily fiber or copper sufficient to provide voice and 4/1 Mbps broadband.

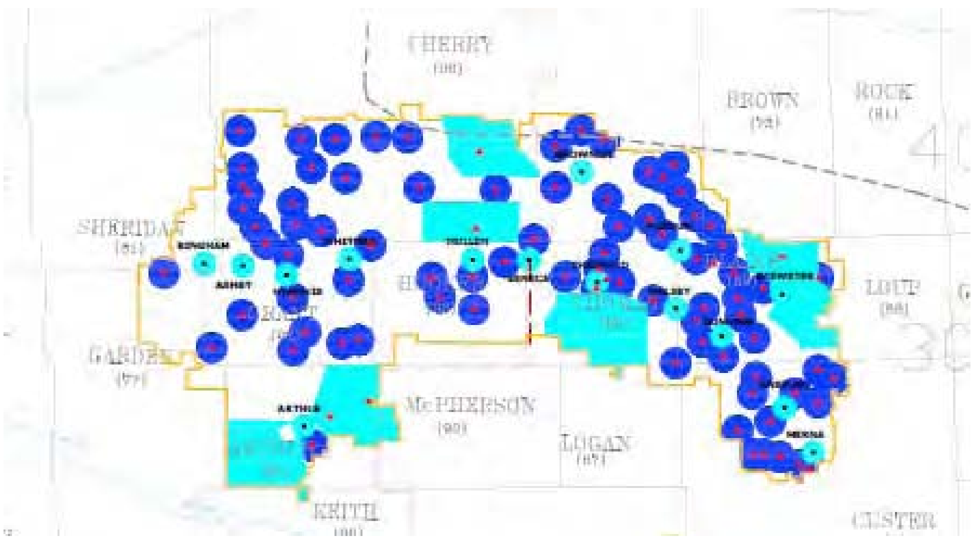


Figure 5-3: Consolidated Companies Upgrade Areas

The area to be upgraded to 4/1 Mbps broadband speed is represented in Figure 5-3 by dark blue circles. The radii for the serving areas were based on 16,000-foot maximum copper distances as described previously. Consolidated has estimated the cost to upgrade the deployed electronics at approximately $500,000. This upgrade would serve an additional 725 subscribers. Therefore, the upgrade cost is estimated at $690 per location. The proposed investment is summarized in Table 5-1.

4/1 Mbps Additional Locations	4/1 Mbps Total Locations	4/1 Mbps % Served	4/1 Mbps Total Investment	4/1 Mbps Investment per Additional Location
725	2504	96%	$ 500,000	$ 690

Table 5-1: Consolidated 4/1 Mbps Upgrade Investment Summary

6 Summary

6.1 Cost Summary

6.1.1 Initial DSL Investment is Less Expensive

As discussed previously, the investments required to deliver 4/1 Mbps broadband to currently unserved households were studied in four GPC exchanges. Consistent with the OBI No. 1, both wireline DSL and wireless LTE networks were designed and engineered. Two primary LTE wireless designs were considered, one with a BHOL of 160 kbps and the other with a BHOL of 444 kbps. Since a BHOL of 160 kbps (25:1 oversubscription) was based on a flawed engineering assumption, this design will not be considered seriously here, but the results are presented for completeness. A summary of the estimated investments required for each network design are shown in Table 6-1.

	Exchange	DSL Wireline (no Oversubscription)	LTE Wireless – BHOL=160 kbps (25:1 Oversubscription)	LTE Wireless – BHOL=444 kbps (9:1 Oversubscription)
Investment	Verdigre	$ 355,000	$ 303,000	$ 563,000
	Stapleton	$ 2,020,000	$ 1,750,000	$ 3,110,000
	Gordon	$ 7,580,000	$ 5,240,000	$ 10,845,000
	Imperial	$ 2,405,000	$ 3,725,000	$ 9,130,000
Totals		**$12,360,000**	**$11,018,000**	**$23,648,000**
Per Unserved Location	Verdigre	$ 9,300	$ 6,900	$ 12,800
	Stapleton	$ 7,600	$ 6,300	$ 11,100
	Gordon	$ 9,000	$ 6,000	$ 12,500
	Imperial	$ 3,000	$ 4,500	$ 11,000

Table 6-1: 4/1 Mbps Design Options Investment Comparison

For each of the four exchanges, the wireline DSL investment is less expensive than the wireless LTE network with 9:1 oversubscription. The unusually large difference between the DSL wireline and LTE wireless investment in Imperial is due to the significant amount of wireline investment that has already been made. The total initial DSL cost for all four GPC exchanges is approximately half of the total initial cost for the wireless LTE network with a BHOL of 444 kbps. For the wireless scenarios, the provider was assumed to have 2x5 MHz of existing spectrum in these areas, and no spectrum costs were included in the investment estimates presented above. If spectrum costs were to be included, the costs would be considerably higher for the wireless LTE network.

Not only is the initial cost of the DSL network significantly lower than the wireless LTE network, it has significantly better performance. First, there is no oversubscription in the DSL access network, so all customers would be able to achieve 4 Mbps simultaneously, even during the busy hour, unless limited somewhere upstream from the access network. In the LTE network, there is 9:1 oversubscription, which means that carriers sell nine times more bandwidth than the actual capacity of the access network. Second, many customers served by DSL can achieve speeds much faster than 4 Mbps. Customers who are located within a mile of the electronics or are served on a FTTP network can achieve broadband speeds of 20 Mbps or more.

6.1.2 Twenty-Year Investment Estimate Shows DSL is Less Expensive

Although the initial capital expenditures for wireline DSL are less than for wireless LTE, the total cost over the life of the assets is more important. Many wireless and wireline network investments have a useful life of twenty years or more. Vantage Point, therefore, estimated the investment required for each network over a twenty-year life. Towers and outside plant were assumed to have a twenty-year life; all electronics were assumed to have a five-year life. Table 6-2 is a summary of these twenty-year investment estimates using 2010 dollars.

	Exchange	DSL Wireline (no Oversubscription)	Wireless – BHOL=160 kbps (25:1 Oversubscription)	Wireless – BHOL=444 kbps (9:1 Oversubscription)
Investment	Verdigre	$ 740,000	$ 860,000	$ 1,465,000
	Stapleton	$ 3,180,000	$ 3,580,000	$ 7,055,000
	Gordon	$ 11,455,000	$ 11,120,000	$ 21,590,000
	Imperial	$ 4,710,000	$ 9,105,000	$ 21,770,000
Total		**$ 20,085,000**	**$ 24,665,000**	**$ 51,880,000**
Per Unserved Location	Verdigre	$ 19,500	$ 19,600	$ 33,300
	Stapleton	$ 12,000	$ 12,800	$ 25,300
	Gordon	$ 13,600	$ 12,800	$ 24,900
	Imperial	$ 5,800	$ 11,000	$ 26,300

Table 6-2: 4/1 Mbps Design Options 20-Year Investment Comparison

Table 6-3 shows the percentage by which DSL wireline investment cost was less expensive than LTE wireless when comparing the technologies' initial costs and the additional investments over a twenty-year period.

Exchange	4/1 Mbps Wireline % Less than Wireless 9:1 Oversubscription Initial Investment	4/1 Mbps Wireline % Less than Wireless 9:1 Oversubscription 20-Year Investment
Verdigre	- 37 %	- 49 %
Stapleton	- 35 %	- 55 %
Gordon	- 30 %	- 47 %
Imperial	- 74 %	- 78 %

Table 6-3: 4/1 Mbps Wireline % Less than Wireless 9:1 Oversubscription

Over a twenty-year life, DSL was found to be between 49 and 78% less expensive than LTE wireless with a BHOL of 444 kbps. Since demand will exceed the capacity of an LTE network in only a few years, analysis of LTE's twenty-year investment cost may be purely academic. DSL technology will be better able to respond to increased demand due to easy scalability, lower oversubscription and DSL's capability to deliver high speeds over short copper loops. Thus, DSL would be both a less expensive and higher-quality investment.

6.2 Case Studies Show OBI Model Flawed

6.2.1 OBI Does Not Accurately Estimate Actual Investments

To determine the accuracy of the OBI Broadband Availability Model, the investments determined by the Vantage Point engineering design were compared to the investment calculated by the OBI Model. The OBI Model's investment estimates were obtained using data mined from the NBP website.[62] Since the OBI investment was calculated by county, the investments were scaled to represent only the portion of the county covered by the exchange.[63] Table 6-4 presents Vantage Point's estimates alongside the OBI's.

Exchange	OBI DSL Model	OBI Wireless Model	DSL Wireline 4/1 Mbps Case Study	LTE Wireless (BHOL=160 kbps) 25:1 Case Study	LTE Wireless (BHOL=444 kbps) 9:1 Case Study
	Total Investment	Total Investment	Total Investment	Total Investment	Total Investment
Verdigre	$ 305,000	$ 160,000	$ 355,000	$ 305,000	$ 565,000
Stapleton	$ 580,000	$ 230,000	$ 2,020,000	$ 1,750,000	$ 3,110,000
Gordon	$ 4,845,000	$ 2,645,000	$ 7,580,000	$ 5,240,000	$ 10,845,000
Imperial	$ 3,535,000	$ 1,390,000	$ 2,405,000	$ 3,725,000	$ 9,130,000

Table 6-4: OBI Investment Compared to Case Studies

Figure 6-1 shows a comparison of the OBI and Vantage Point case study investments.

[62] http://www.broadband.gov/plan/deployment-cost-model.html.
[63] See Section 4 for more detail on how the OBI investment estimates were scaled to exchange areas.

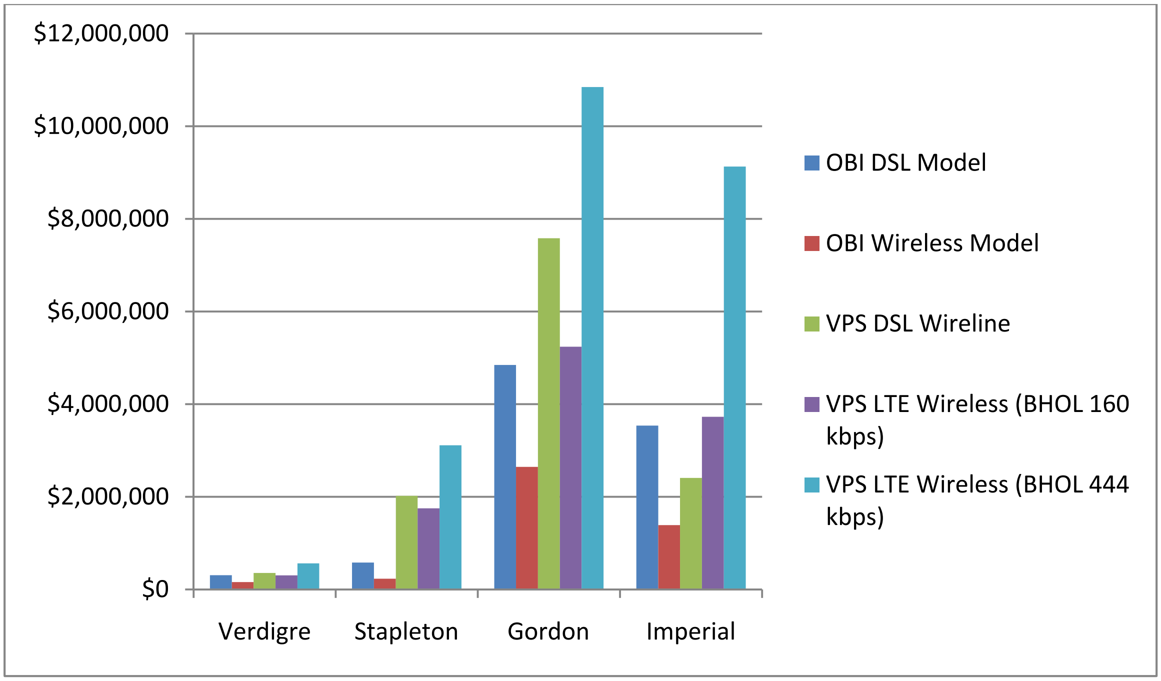


Figure 6-1: Comparison of OBI and Case Study Investment Estimates

Table 6-5 shows the comparison on a per unserved location basis.

Exchange	OBI DSL Model	OBI Wireless Model	DSL Wireline 4/1 Mbps Case Study	LTE Wireless (BHOL=160 kbps) 25:1 Case Study	LTE Wireless (BHOL=444 kbps) 9:1 Case Study
	Investment Per Unserved Location	Investment Per Unserved Location	Investment Per Unserved Location	Investment Per Unserved Location	Investment Per Unserved Location
Verdigre	$ 6,900	$ 3,600	$9,300	$ 6,900	$ 12,800
Stapleton	$ 2,100	$ 800	$7,600	$ 6,300	$ 11,100
Gordon	$ 5,600	$ 3,000	$9,000	$ 6,000	$ 12,500
Imperial	$ 4,300	$ 1,700	$3,000	$ 4,500	$ 11,000

Table 6-5: Per Unserved Location OBI Investment Compared to Case Studies

The OBI investment estimates varied significantly from the investments determined by engineering designs. In most cases, the OBI model did not accurately estimate either the wireless or wireline investments. Vantage Point was unable to determine a consistent pattern of error.

6.2.2 OBI Model Does Not Accurately Estimate the Unserved

In several exchange areas, the OBI No. 1 indicates that availability of broadband services is significantly different from what actually is available.[64] For example, the Stapleton exchange is primarily located in Logan County, which according to the OBI No. 1 has 96 to 100% broadband availability. A portion of Exhibit 2-B is reproduced in Figure 6-2 with the Stapleton exchange boundary shown.

[64] OBI No. 1, Figure 2-B, p. 18.

Figure 6-2: Lincoln, Logan, and McPherson County Portion of OBI Exhibit 2-B

Broadband speeds at or exceeding 4 Mbps are available to 45% of customers in the Stapleton exchange. Since the Stapleton exchange covers 80% of Logan County, it is likely that the OBI No. 1 overestimated the county's broadband availability by about 50%.

The Imperial exchange covers 74% of Chase County and a small portion of Dundy County. The OBI No. 1 indicates that Chase County has 81 to 90% availability of broadband capable networks.[65] A portion of the OBI's Exhibit 2-B is reproduced in Figure 6-3 with the Imperial exchange boundary shown.

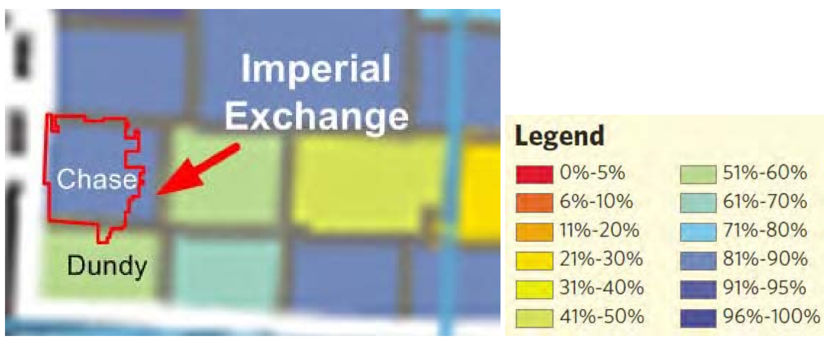


Figure 6-3: Chase and Dundy County Portion of OBI Exhibit 2-B

Since the Imperial exchange covers most of Chase County and has only 61% broadband availability, the OBI No. 1 likely overstates availability in Chase County by about 20%. For the GPC exchanges studied, Vantage Point found that broadband availability was consistently overestimated in the OBI No. 1.

There are four counties in which Consolidated provides service to 95% or more of the county's population: Thomas, Hooker, Blaine, and Grant. Figure 6-4 displays the OBI's availability estimates for these counties.

[65] Id. Exhibit 2-B, p. 18.

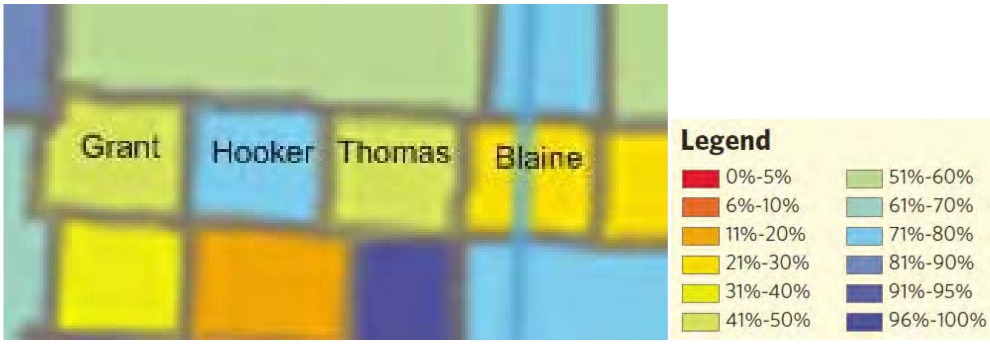


Figure 6-4: OBI Exhibit 2-B for Consolidated Service Territory

The OBI's broadband availability range was correct only for Hooker County. In the other three counties, the OBI underestimated broadband availability by between 10 and 30%. In Table 6-6, the OBI's broadband availability estimates are displayed alongside availability data from GPC and Consolidated.

County	Actual 4/1 Mbps Availability	OBI Estimated Availability	Approximate Percentage Difference
Logan	45%	96 to 100%	Overestimated by 50%
Chase	61%	81 to 90%	Overestimated by 20%
Hooker	79%	71 to 80%	No Difference
Thomas	72%	41 to 50%	Underestimated by 20%
Grant	58%	41 to 50%	Underestimated by 10%
Blaine	62%	21 to 30%	Underestimated by 30%

Table 6-6: OBI Broadband Availability Compared to Case Study

As demonstrated above, the OBI's Broadband Availability Model does not accurately predict the availability of broadband and frequently overestimates or underestimates availability by 20% or more.

6.2.3 OBI Model Overstates Spectrum Availability

The OBI No. 1 assumes 2 x 20 MHz of spectrum is available, even though it admits that "no U.S. service provider currently has more than 2 x 10 MHz of contiguous spectrum in the 700 MHz band."[66] Unless significant amounts of spectrum are made available within the next several years, such an assumption is unrealistic. If companies own spectrum in rural areas, they commonly own 2 x 5 MHz. Verizon Wireless, the largest wireless provider in the United States, won the Upper 700 MHz C band auction, netting 2 x 11 MHz of contiguous 700 MHz spectrum, but it is highly unlikely that Verizon would consider partitioning or leasing the 2 x 11 MHz spectrum in a particular geographic area. As such, 2 x 5 MHz of spectrum was assumed for the case studies described in Section 4.

[66] Id., p. 80.

As shown in the wireless LTE case studies and noted in the OBI No. 1, to alleviate capacity constraints additional spectrum bands can be utilized in conjunction with the 700 MHz spectrum from the same tower locations in an overlay per underlay configuration.[67] When additional spectrum was assumed in the case studies,[68] the three 2 x 5 MHz bands were not contiguous. LTE-Advanced equipment will allow for aggregation of noncontiguous spectrum, but it is highly unlikely that a commercially available LTE-Advanced product will be available before the network assumed in the OBI No. 1 would need to be built, since the LTE-Advanced technical specifications have not yet been completed by the 3GPP organization.

6.2.4 OBI Model Understates New Tower Construction

The OBI No. 1 indicates that nationwide, new tower construction would be required 15% of the time.[69] However, Vantage Point determined that new towers would be needed much more frequently. Table 6-7 summarizes the percentages of new towers that would need to be built for the 160 kbps BHOL designs.

Exchange	Required Sites	Required New Sites	Percentage of New Towers
Verdigre	1	0	0%
Stapleton	3	2	67%
Imperial	7	6	86%
Gordon	8	5	63%

Table 6-7: New Tower Percentages for 160 kbps BHOL Studies

When a more realistic assumption of 444 kbps BHOL with 2 x 5 MHz of spectrum is designed, each sector can support fewer subscribers. Therefore, more new towers are required, as shown in Table 6-8.

Exchange	Required Sites	Required New Sites	Percentage of New Towers
Verdigre	2	0	0%
Stapleton	7	6	86%
Imperial	20	19	95%
Gordon	19	19	100%

Table 6-8: New Tower Percentages for 444 kbps BHOL Studies

If an additional 2 x 5 MHz of spectrum is available, even with an assumed BHOL of 444 kbps, the percentages of new towers needed are the same as in the 160 kbps BHOL designs, as shown in Table 6-9.

[67] Id., p. 80.
[68] Sections 4.1.3.3, 4.2.3.3, 4.3.3.3, and 4.4.3.3.
[69] Id., p. 82.

Exchange	Required Sites	Required New Sites	Percentage of New Towers
Verdigre	1	0	0%
Stapleton	3	2	67%
Imperial	7	6	86%
Gordon	8	5	63%

Table 6-9: New Tower Percentages for 444 kbps BHOL with Additional Spectrum Studies

6.3 LTE Has Significantly Higher Cost as Function of Speed

To compare the cost of bandwidth between network designs, the case study investment was divided by the total bandwidth available in each of the designs. For the wireline scenario, the total bandwidth was determined by multiplying the number of customer locations by the bandwidth available in the access network per subscriber (4 Mbps). For the wireless scenarios, the total bandwidth available from each tower was multiplied by the number of towers in the design. For both wireline and wireless designs, the investment was divided by the calculated access network bandwidth to estimate the cost per Mbps, which is shown in Table 6-10.

Exchange	4/1 Mbps Wireline No Oversubscription	4/1 Mbps Wireless (BHOL=160 kbps) 25:1 Oversubscription	4/1 Mbps Wireless (BHOL=444 kbps) 9:1 Oversubscription
Verdigre	$ 2,328	$ 13,356	$12,482
Stapleton	$ 1,899	$ 25,904	$ 19,722
Gordon	$ 2,247	$ 29,137	$ 25,375
Imperial	$ 739	$ 23,645	$ 20,293

Table 6-10: Cost ($) per Mbps of Access Network Capacity

The wireline designs offer a cost per Mbps that is 5 to 30 times lower than the wireless designs. As the wireline networks are upgraded, the available broadband capacity increases much faster than the cost, as seen in Table 6-11 where the cost per Mbps shows a significant reduction for 20 Mbps and even more for 100 Mbps networks. Since increasing the broadband capacity of a wireless network requires a significant investment, these dramatic reductions in cost per Mbps would not be expected.

Exchange	20 Mbps Wireline No Oversubscription	100 Mbps Wireline No Oversubscription
Verdigre	$ 540	$ 56
Stapleton	$ 625	$ 94
Gordon	$ 521	$ 71
Imperial	$ 397	$ 60

Table 6-11: Cost ($) per Mbps of Access Network Capacity

6.4 Future Broadband Growth – Network Scalability

6.4.1 Wireless Broadband Speed Growth

To determine the scalability of an LTE network, an additional wireless network was designed for GPC's Gordon exchange. A BHOL of 3.75 Mbps per household was assumed, thus eliminating oversubscription to make the wireless network more comparable in performance to the wireline 4/1 Mbps DSL design. 3.75 Mbps, rather than 4 Mbps, was assumed because a BHOL of 4 Mbps per household results in an uneconomic network with only one subscriber per sector.[70] A BHOL of 3.75 Mbps results in the network constraint of two subscribers per sector, as illustrated in the following equation:

$$\frac{(5\ MHz) * \left({}^{1.5\ bps}\!/_{Hz} \Big/ _{Sector} \right)}{\left({}^{3.75\ Mbps}\!/_{subscriber} \right)} = 2\ \text{subscribers/sector}$$

Equation 6-1: 3.75 Mbps with 2 x 5 MHz of Spectrum BHOL Subscribers

Under this scenario, 146 new trisector LTE sites would need to be constructed to serve 866 locations.

Table 6-12 summarizes the estimated investment costs.

4/1 Mbps Additional Locations	4/1 Mbps Total Locations	4/1 Mbps % Served	4/1 Mbps Core Network Electronics Investment	4/1 Mbps RAN Electronics Investment	4/1 Mbps CPE Investment	4/1 Mbps LTE Wireless Total Investment	4/1 Mbps Investment per Additional Location
866	1962	100%	$145,000	$91,110,000	$605,000	$91,860,000	$106,000

Table 6-12: Gordon Exchange 3.75 Mbps with 2 x 5 MHz of Spectrum

To deliver 3.75 Mbps broadband with no oversubscription in the access network to all locations in the Gordon exchange using LTE, an investment of $106,000 per additional location would be required.

Since building over one-hundred towers would prove extremely expensive and impractical, Vantage Point estimated the cost of the design should the carrier instead purchase three additional 2 x 5 MHz of spectrum. The carrier would then own 40 MHz of spectrum, an uncommonly large amount. Under this scenario, eight subscribers can be served per sector, as shown in the following equation:

[70] Each sector has only 2 x 5 MHz of spectrum, which results in only 7.5 Mbps of capacity assuming a spectral efficiency of 1.5 bps/Hz.

$$\frac{(5\ MHz) * \left({}^{1.5\ bps}/_{Hz} \Big/ {Sector} \right)}{\left({}^{3.75\ Mbps}/_{subscriber} \right)} + \frac{(5\ MHz) * \left({}^{1.5\ bps}/_{Hz} \Big/ {Sector} \right)}{\left({}^{3.75\ Mbps}/_{subscriber} \right)} + \frac{(5\ MHz) * \left({}^{1.5\ bps}/_{Hz} \Big/ {Sector} \right)}{\left({}^{3.75\ Mbps}/_{subscriber} \right)} + \frac{(5\ MHz) * \left({}^{1.5\ bps}/_{Hz} \Big/ {Sector} \right)}{\left({}^{3.75\ Mbps}/_{subscriber} \right)}$$

$$= 8\ \text{subscribers/sector}$$

Equation 6-2: 3.75 Mbps with 2 x 20 MHz of Spectrum BHOL Subscribers

When additional spectrum is assumed, 35 trisector LTE sites are required.

Table 6-13 summarizes the associated investment costs.

4/1 Mbps Additional Locations	4/1 Mbps Total Locations	4/1 Mbps % Served	4/1 Mbps Core Network Electronics and Additional Spectra Investment	4/1 Mbps RAN Electronics Investment	4/1 Mbps CPE Investment	LTE Wireless 4/1 Mbps Total Investment	4/1 Mbps Investment per Additional Location
866	1962	100%	$6,470,000	$28,695,000	$605,000	$35,770,000	$41,300

Table 6-13: Gordon Exchange 3.75 Mbps with 2 x 20 MHz of Spectrum

The addition of 35 trisector LTE sites and procurement of three additional 2 x 5 MHz bands of spectrum would increase the availability of 3.75 Mbps broadband to all of the locations within the exchange area at a cost of $41,300 per additional location.

6.4.2 Comparison of Wireless and Wireline Bandwidth Growth Options

Table 6-14 compares the cost of the 3.75 Mbps wireless design with no oversubscription to the costs of 20 and 100 Mbps wireline designs.[71]

[71] See Section 4 for more information on the 20 and 100 Mbps designs.

	Exchange	20 Mbps Design	100 Mbps Design	Wireless (3.75 Mbps Design)
Investment	Verdigre	$ 765,000	$ 2,080,000	
	Stapleton	$ 3,785,000	$ 4,750,000	
	Gordon	$ 9,840,000	$ 13,975,000	$ 35,770,000
	Imperial	$ 6,735,000	$ 12,560,000	
Per Unserved Location	Verdigre	$ 10,800	$ 5,600	
	Stapleton	$ 12,500	$ 9,400	
	Gordon	$ 10,400	$ 7,100	$ 41,300
	Imperial	$ 8,000	$ 6,000	

Table 6-14: Bandwidth Growth Options Investment Comparison

As shown in the Gordon exchange, the wireless 3.75 Mbps design requires significantly more investment than either the 20 Mbps or 100 Mbps wireline designs.

6.5 Serving the Highest Cost Customers with Satellite

The OBI No. 1 also observes that a small percentage of subscribers cannot be reached with wireline or terrestrial wireless service.[72] Although the wireless designs assumed that all subscribers would be reached, in reality a small number of locations may not receive service due to terrain or obstruction issues that could not be foreseen in the RF analysis. As discussed in Section 4 of this document, the 20 Mbps and 100 Mbps case study designs would provide all subscribers with the specified level of broadband, but the 4/1 Mbps designs had a small number of households that could not be feasibly reached. For the 4/1 Mbps designs, satellite broadband could provide broadband to some of the unserved customers. The satellite broadband service, however, would be a lower-quality service than the designs studied in these case studies.

6.5.1 Current/Future Satellite Capabilities and Limitations

Satellite broadband is normally delivered to customers using geostationary satellites which orbit the earth at the same speed as the earth rotates. They are, therefore, stationary relative to the earth. Such satellites orbit approximately 22,300 miles above the equator, and since the signal travels more than 44,000 miles, satellite broadband has high latency and typically is not suitable for delivery of interactive multimedia. Most networks used to deliver time sensitive traffic, such as voice and interactive video, are designed to have less than 120 to 150 ms of latency. The roundtrip delay of a satellite signal is nearly four times this much.

To decrease latency, some efforts to deploy medium and low earth orbiting satellites have been attempted. When satellites are only a few hundred miles above the earth, the satellites orbit the earth so rapidly that many satellites are required to ensure a constant line-of-sight. When used for broadband, these satellite systems have historically proven to be too complex and expensive to deploy

[72] OBI No. 1, p. 89.

effectively. While advancements in satellite technology have increased the bandwidth that can be delivered, the bandwidth is shared among many subscribers. Like other broadband delivery systems with a shared access network, satellite's available bandwidth per customer decreases as the number of customers increases. Because of these limitations, satellite broadband should only be considered for very remote areas where no feasible alternative exists.

6.6 Conclusion

The OBI Model is based on the belief that a 4/1 Mbps broadband target will meet customer demands today and in the near future. This target will not reduce the digital divide, but rather increase it. At least 7 million customers will be destined to become second-class citizens in our digital age. Unfortunately, these rural customers need adequate broadband the most.

The OBI Model contained a clear bias toward a wireless design by understating the actual wireless costs. As shown in the case studies, the Model underestimated the number of towers that would need to be constructed, had overly aggressive assumptions regarding the use of microwave backhaul, and assumed an unrealistic amount of spectrum to be available. The Model also assumed an artificially low BHOL, which lowered the broadband threshold enough to allow a wireless network to be a realistic alternative. Unfortunately, a network based on these design parameters will not provide the needed 4/1 Mbps and will not meet customers' broadband needs. These problems will worsen with time as streaming traffic becomes more prevalent.

Whereas the Model overstated existing wireless infrastructure, it understated the capability of the current wireline network. Many of the unserved customers were shown to be in areas already served by wireline infrastructure, which can often be upgraded to provide 4/1 Mbps broadband speeds or faster. Additionally, wireline networks are not plagued with many of the performance issues that are inherent in wireless network designs.

In terms of both cost and performance, wireline 4/1 Mbps designs with no oversubscription are superior to wireless 4/1 Mbps designs with realistic BHOL assumptions. The cost advantage of wireline was evident when the initial investments were compared and became more pronounced when twenty-year investments estimates were considered.[73] The DSL designs have better performance than LTE designs, since DSL access networks are not oversubscribed and can provide higher broadband speeds. Additionally, wireline offers far lower investment cost per Mbps than wireless and can be more cost effectively upgraded to meet future demand.

[73] Over a twenty-year life, the wireline design was even less expensive than the wireless design with an unrealistically low BHOL assumption of 160 kbps.

Appendix A – Vantage Point Overview

Vantage Point Background

Vantage Point Solutions, Inc. (Vantage Point) is a telecommunications engineering and consulting company that provides Professional Engineering Services, as well as regulatory and financial consulting services, to a variety of telecommunications companies and other industries. Vantage Point has over 110 fulltime employees, including seven Licensed Professional Engineers. Vantage Point has designed and engineered hundreds of broadband access networks for telecommunications companies across the United States.

Vantage Point has reviewed "The Broadband Availability Gap, OBI No. 1"[74] which was an attachment to the USF NPRM[75]. Vantage Point's areas of expertise are broad and include nearly all elements of a modern wireless and wireline telecommunications network including the following:

- Wireline Broadband Access Design and Engineering
  - Copper and Deep Fiber Networks
  - Fiber to the Premises (FTTP)
- Wireless Broadband Access Design and Engineering
  - Fixed wireless networks
  - Mobile wireless networks
- Middle Mile Design and Engineering
  - Fiber Optic Transport (SONET and Packet Networks)
  - Microwave backhaul
- Switching Network Design and Engineering
  - Voice networks, including Voice over IP
  - Packet Networks
- Outside Plant (OSP) Design and Engineering
  - Copper OSP Architectures (including Fiber in the Loop)
  - Fiber OSP Architectures (Fiber to the Premises)
  - Buried and Aerial Construction

The Vantage Point staff has hundreds of years of expertise in engineering services for telecommunications companies. Some have been working in the industry more than 40 years. In the last eight years, Vantage Point has designed more than 10,000 miles of OSP construction for locations across the county.

Vantage Point has designed and engineered fixed and mobile wireless networks for both licensed and unlicensed spectrum. Vantage Point is familiar with the wireless technology alternatives required to support the wireless deployment, such as customer premises equipment, packet data, core and networks,, the business aspects of wireless implementation, such as business plans, interconnection

[74] The Broadband Availability Gap, OBI Technical Paper No. 1, Federal Communications Commission, April 2010.
[75] In the Matter of Connect America Fund, A National Broadband Plan for Our Future High-Cost Universal Support, FCC 10-58, Released April 21, 2010.

agreements, roaming agreements, billing requirements, and other ancillary systems). In addition, Vantage Point assists clients in acquiring spectrum and provides wireless business consulting services.

Vantage Point has the expertise and the real world experience to understand the capabilities and costs associated with broadband deployment. Our experience allows us to differentiate actual capabilities from the misinformation prevalent in the industry.

The following are biographies of the primary Vantage Point staff that prepared this study.

Larry D. Thompson, PE - CEO

Larry has been an active participant in the telecommunications industry since 1985. He received a Bachelors of Arts in Physics (1983) from William Jewell College, a Bachelors of Science in Electrical Engineering (1985) from the University of Kansas, and a Masters of Science in Electrical and Computer Engineering (1986) from the University of Kansas. He is uniquely qualified to lead Vantage Point Solutions in the ever-evolving telecommunications industry. Larry has a proven track record in both the technical and leadership challenges of the business. Prior to Vantage Point Solutions, Larry was General Manager for the Telecom Consulting and Engineering (TCE) Business Unit of Martin Group (Mitchell, SD), was a Sr. Engineer for CyberLink Corporation (Boulder, CO), and worked as a member of the technical staff at TRW (Redondo Beach, CA).

From a technical standpoint, Larry has expertise in the design and implementation of voice, data, and video networks. Larry designed and implemented some of the largest Digital Subscriber Line (DSL) and Fiber-to-the-Premises (FTTP) video deployments in ILEC service areas. Larry also is an associate member of the NECA Rate Development Task Force. He assists many telephone companies with their strategic planning and is a frequent expert witness at utility commission and legal proceedings relating to telecommunication technology and regulatory matters.

Larry is a registered Professional Engineer (PE) in the states of Colorado, Georgia, Idaho, Iowa, Indiana, Michigan, Minnesota, Missouri, Nebraska, New York, Ohio, South Dakota, Utah, Wisconsin, and Wyoming. He is a member of several engineering, math, and physics societies, including Eta Kappa Nu, Tau Beta Pi, Sigma Pi Sigma, and Kappa Mu Epsilon.

Brian P. Enga, PE - Senior Engineering Team Member

Brian has been a member of the telecommunications industry since 1999. He received Bachelor of Science degrees in Electrical Engineering and Engineering Physics from South Dakota State University in 1995.

During his career, Brian has been actively involved in the migration and implementation aspects of access networks in the ILEC marketplace. These areas have included coax based systems, fiber-based networks (FTTP) and copper-based networks (ADSL and VDSL). He has also expertise in analog and digital video headends (QAM, IP and ATM), middleware solutions, and video set-top boxes. Brian completed the technical research, plans and specifications development, vendor evaluation, project management, and final inspection for these deployments.

Brian has also coordinated many RUS loan design submittals and is experienced with the RUS Loan Design requirements, timelines, and procedures.

Prior to Vantage Point Solutions, Brian was part of the Engineering Staff at Martin Group. Brian is a registered Professional Engineer (PE) in the states of South Dakota and Alaska.

Warren Vande Stadt – Senior Technology Leader - Wireless

Warren Vande Stadt has provided multiple facets of wireless system planning including various RF technologies, switching, transport/backhaul, microwave, DC plant, ancillary platforms and technical implementations, along with traffic interchange negotiation and regulatory and business/operations planning, bringing over 25 years of prior wireless industry experience to bear. Warren came to Vantage Point Solutions in 2002 from the Radio Carriers' Service Co., Inc., a wireless consulting and contracting firm he formed and served as President of for 12 years. His firm provided technical operations management assistance for cellular, PCS and other wireless carriers, and accomplished numerous analysis and construction tasks for both small and large markets.

Mr. Vande Stadt formed RCSCo, Inc. out of a wealth of experience in cellular network construction and operations, beginning with construction of one of the nation's first major market non-wireline cellular systems in Virginia Beach-Norfolk-Newport News and his management of network operations there as Director of Engineering for Cellular One of Southeastern Virginia, 1985-1987. From 1988 to 1990, he planned and built the Rapid City, SD non-wireline cellular system "from the ground up" on-site, and then continued to manage technical operations and staff for it and 13 other mid-sized MSAs as Director of Engineering for Cellular Information Systems in Denver. Following this he joined Dakon Cellular, Inc. in Sioux Falls, SD as Director of Engineering, where he wrote detailed business plans and oversaw network planning, construction and operations management for RSA cellular systems. He formed RCSCo two years later in 1992 when Dakon elected to exit the business. Mr. Vande Stadt thus has experience in all facets of cellular/PCS network construction and management, spanning nearly the total length of time the industry itself has been commercially viable.

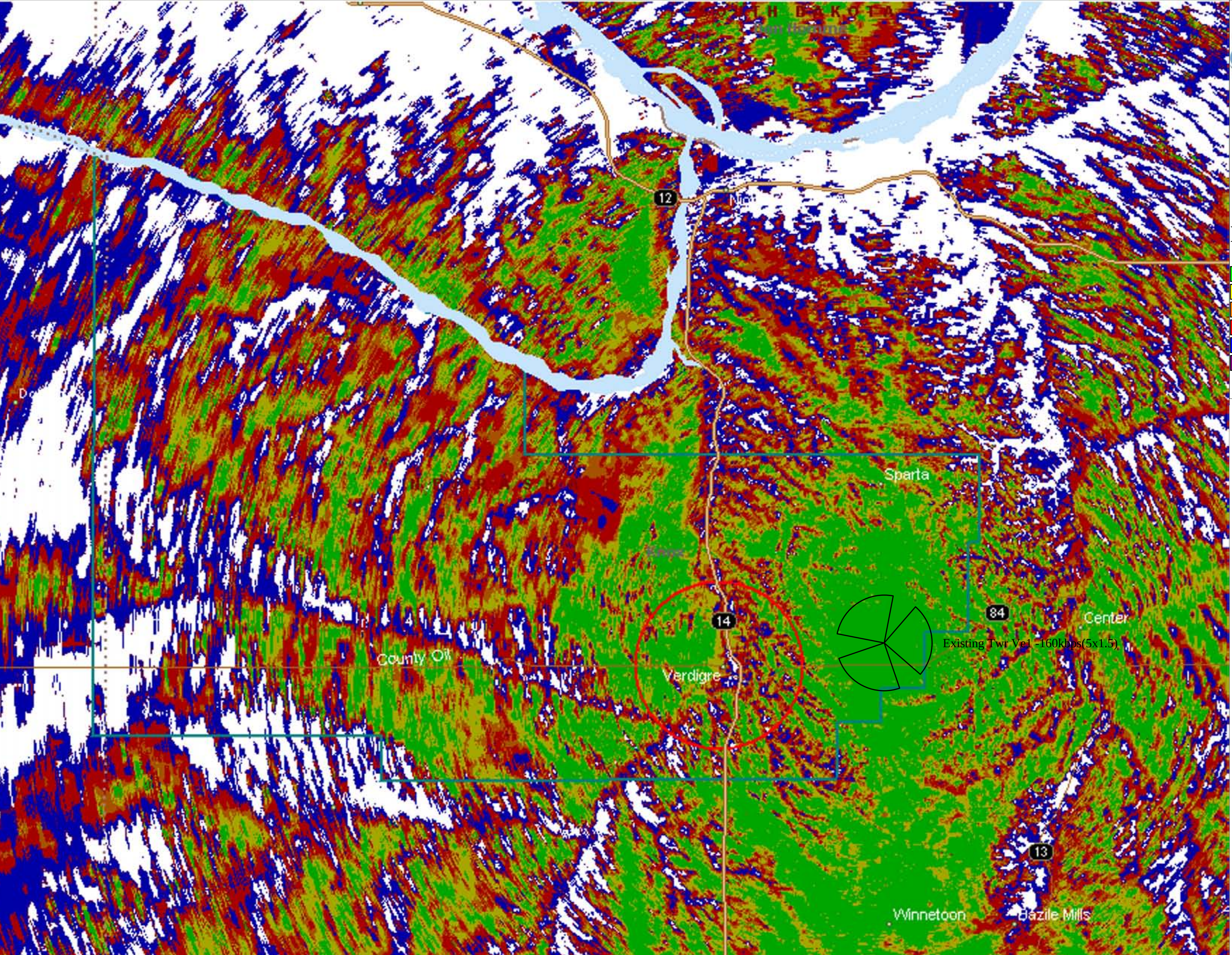
Mr. Vande Stadt received his technical training from the Ervin Institute of Electronics and his business training from the University of Cincinnati, and holds an FCC General (First Class) Radiotelephone Operator's License with Radar Endorsement.

Brian W. Bell – Engineering Team Member

Brian has been an active participant in the telecommunications industry since 1999. Brian was employed as a telecommunications technician while earning a Bachelor of Science degree in Electrical Engineering (2003) from South Dakota School of Mines & Technology (SDSM&T). Brian joined the engineering staff of Vantage Point Solutions in 2004. Since joining Vantage Point Solutions, Brian has been involved with the implementation of many components of telecommunications networks including unlicensed and licensed wireless, FITL, FTTP, standby power, and Central Office grounding.

Brian has been responsible for the RF design and evaluations for wireless networks, conducting Central Office power and grounding audits, performing ground field measurements, performing soil resistivity measurements, and designing Central Office ground fields based upon the soil resistivity measurements. Brian has also been responsible for the technical research, development of plans and specifications, vendor evaluation, project management, and final inspections.

Appendix B – RF Plots



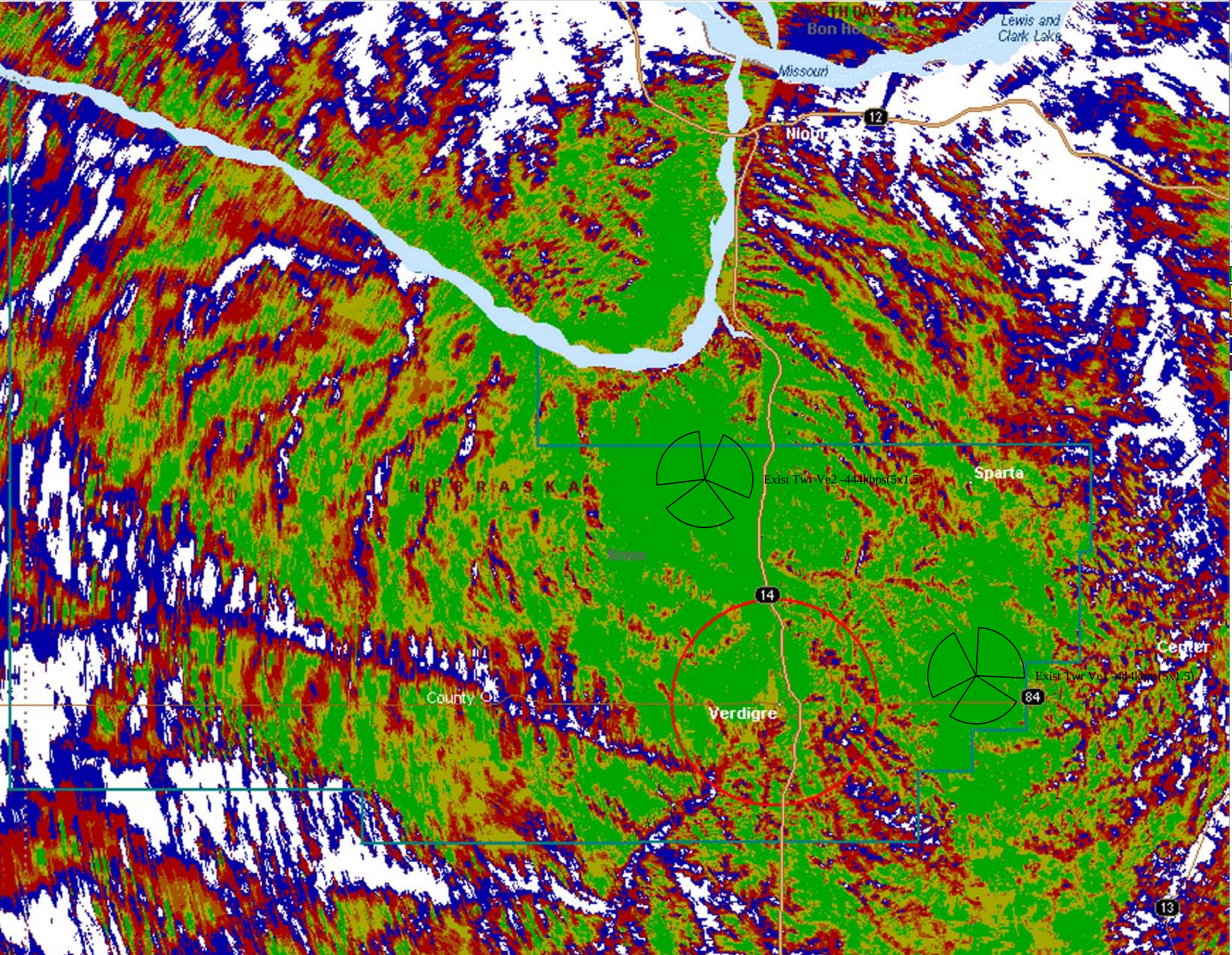
700MHz LTE System

4Mbps Service with a Busy Hour load assumption of 160kbps, assuming 5MHz Channels at 1.5bits/Hz

Legend -- Signal in dBm

Green	0.00 >= n > -75.00
Yellow	-75.00 >= n > -85.00
Orange	-85.00 >= n > -90.00
Red	-90.00 >= n > -100.00
Blue	-100.00 >= n > -110.00
Purple	-110.00 >= n > -115.00

Verdigre Exchange



GREAT PLAINS COMMUNICATIONS

VantagePoint

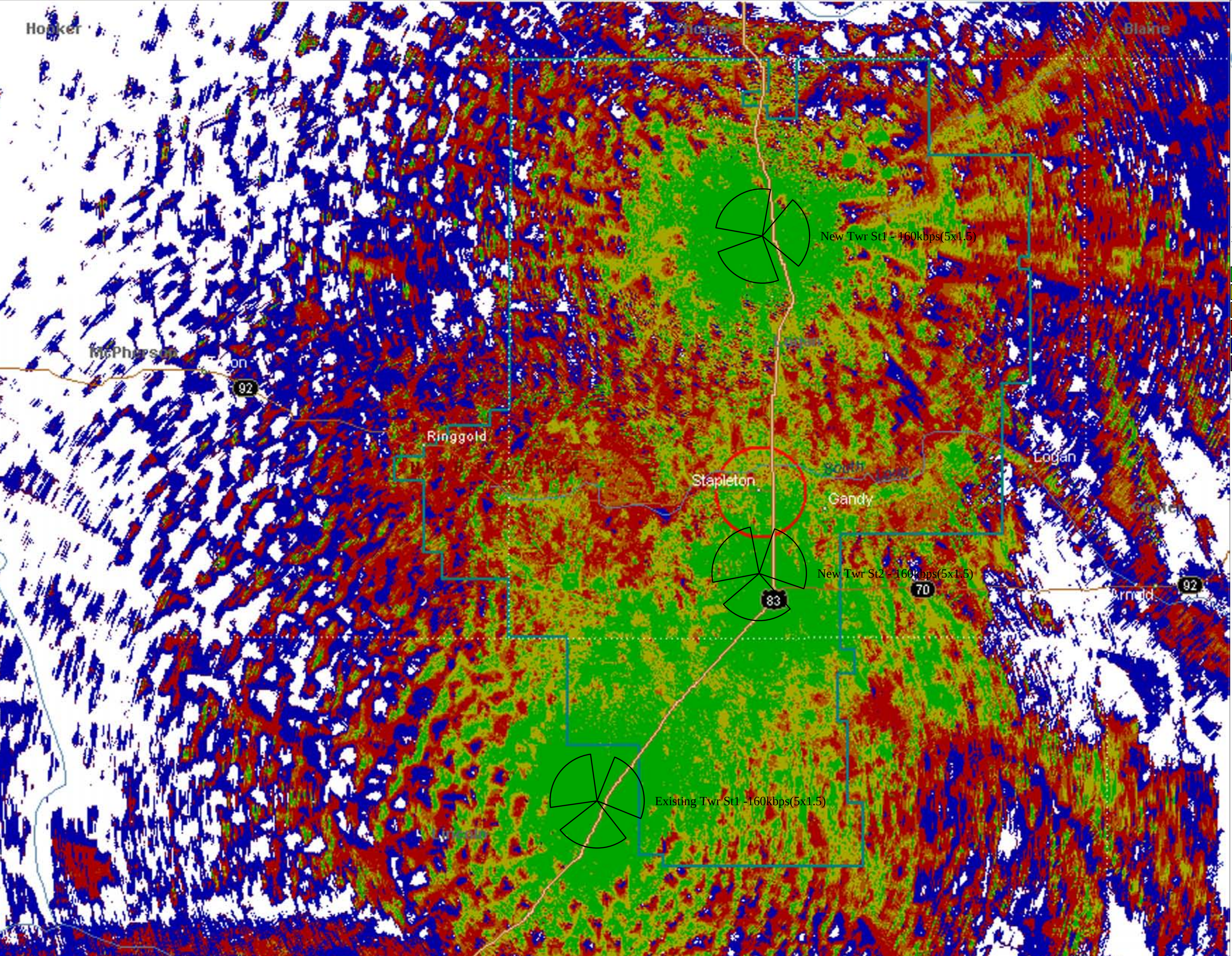
700MHz LTE System

4Mbps Service with a Busy Hour load assumption of 444kbps, assuming 5MHz Channels at 1.5bits/Hz

Legend -- Signal in dBm

- 0.00 >= n > -75.00
- -75.00 >= n > -85.00
- -85.00 >= n > -90.00
- -90.00 >= n > -100.00
- -100.00 >= n > -110.00
- -110.00 >= n > -115.00

Verdigre Exchange



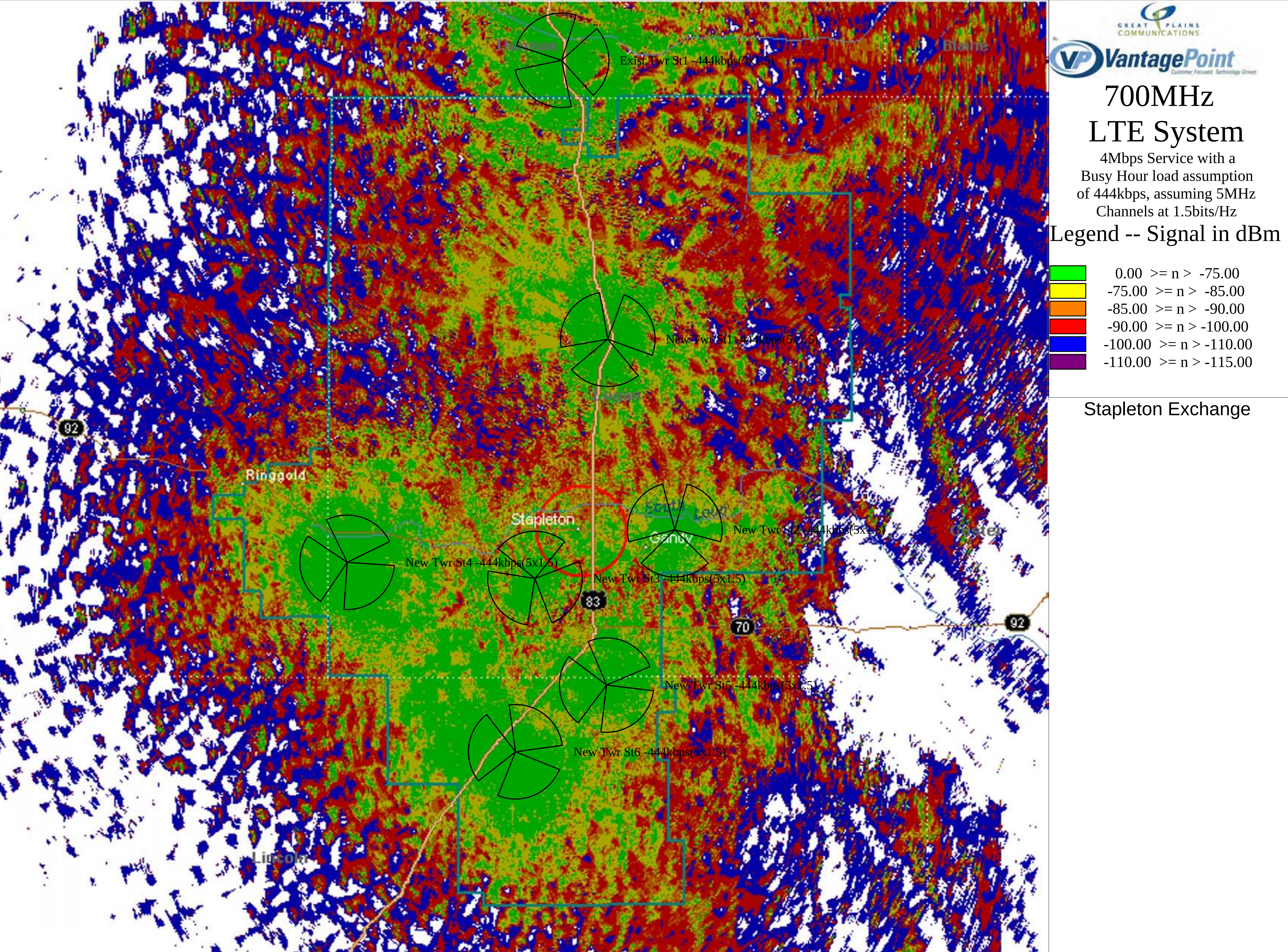
700MHz LTE System

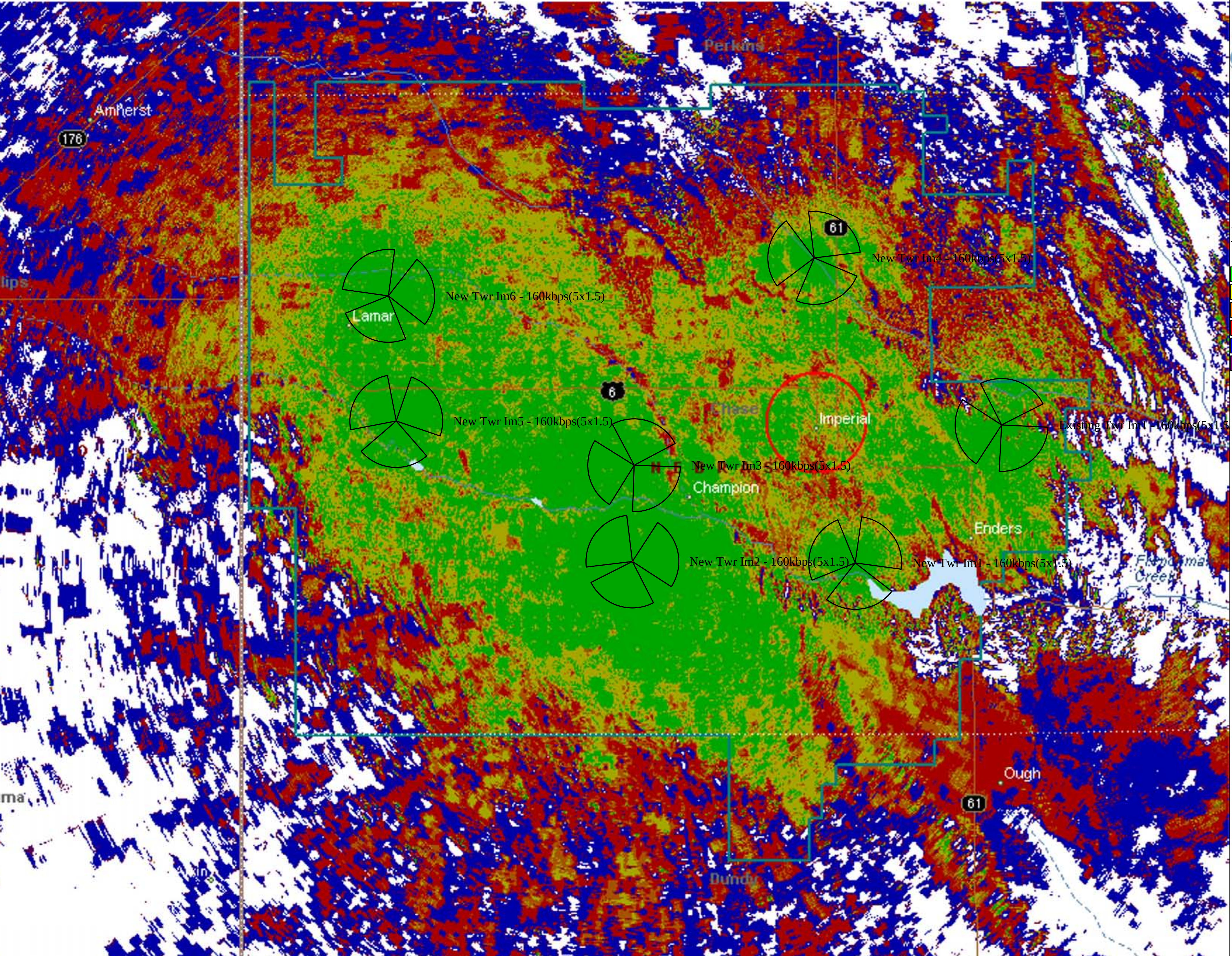
4Mbps Service with a Busy Hour load assumption of 160kbps, assuming 5MHz Channels at 1.5bits/Hz

Legend -- Signal in dBm

Green	0.00 >= n > -75.00
Yellow	-75.00 >= n > -85.00
Orange	-85.00 >= n > -90.00
Red	-90.00 >= n > -100.00
Blue	-100.00 >= n > -110.00
Purple	-110.00 >= n > -115.00

Stapleton Exchange


GREAT PLAINS COMMUNICATIONS
VantagePoint
700MHz
LTE System
4Mbps Service with a
Busy Hour load assumption
of 444kbps, assuming 5MHz
Channels at 1.5bits/Hz
Legend -- Signal in dBm
0.00 >= n > -75.00
-75.00 >= n > -85.00
-85.00 >= n > -90.00
-90.00 >= n > -100.00
-100.00 >= n > -110.00
-110.00 >= n > -115.00
Stapleton Exchange
Exist Twr St1 -444kbps(5x1.5)
New Twr St1 -444kbps(5x1.5)
New Twr St2 -444kbps(5x1.5)
New Twr St3 -444kbps(5x1.5)
New Twr St4 -444kbps(5x1.5)
New Twr St5 -444kbps(5x1.5)
New Twr St6 -444kbps(5x1.5)
Ringgold
Stapleton
Gandy
Logan
Lincoln
Blaine
Custer
92
83
70
92



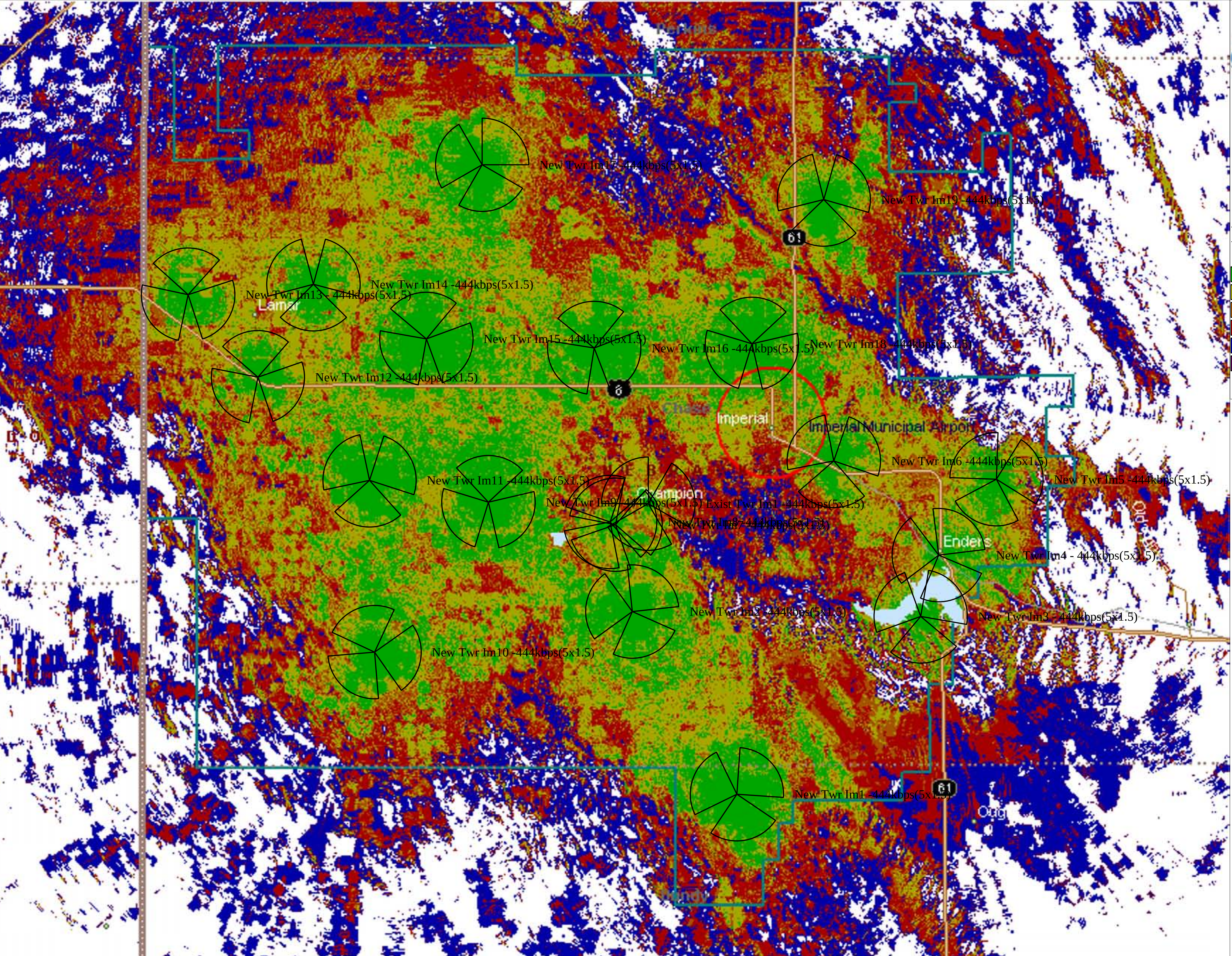
700MHz LTE System

4Mbps Service with a Busy Hour load assumption of 160kbps, assuming 5MHz Channels at 1.5bits/Hz

Legend -- Signal in dBm

(green)	0.00 >= n > -75.00
(yellow)	-75.00 >= n > -85.00
(orange)	-85.00 >= n > -90.00
(red)	-90.00 >= n > -100.00
(blue)	-100.00 >= n > -110.00
(purple)	-110.00 >= n > -115.00

Imperial Exchange



GREAT PLAINS COMMUNICATIONS

VantagePoint

Customer Focused. Technology Driven

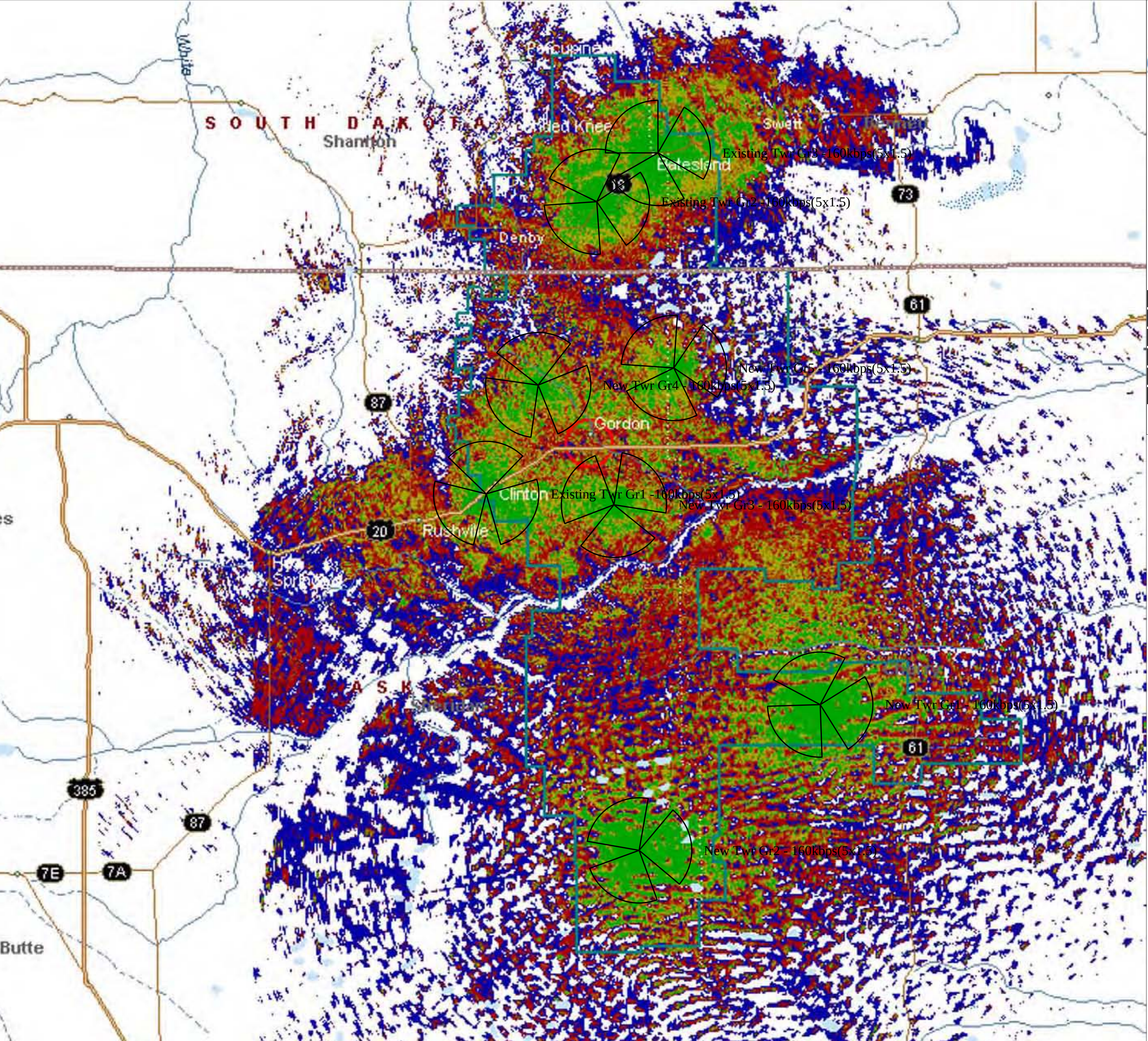
700MHz LTE System

4Mbps Service with a Busy Hour load assumption of 444kbps, assuming 5MHz Channels at 1.5bits/Hz

Legend -- Signal in dBm

0.00 >= n > -75.00
-75.00 >= n > -85.00
-85.00 >= n > -90.00
-90.00 >= n > -100.00
-100.00 >= n > -110.00
-110.00 >= n > -115.00

Imperial Exchange



GREAT PLAINS COMMUNICATIONS

VantagePoint
Customer Focused. Technology Driven

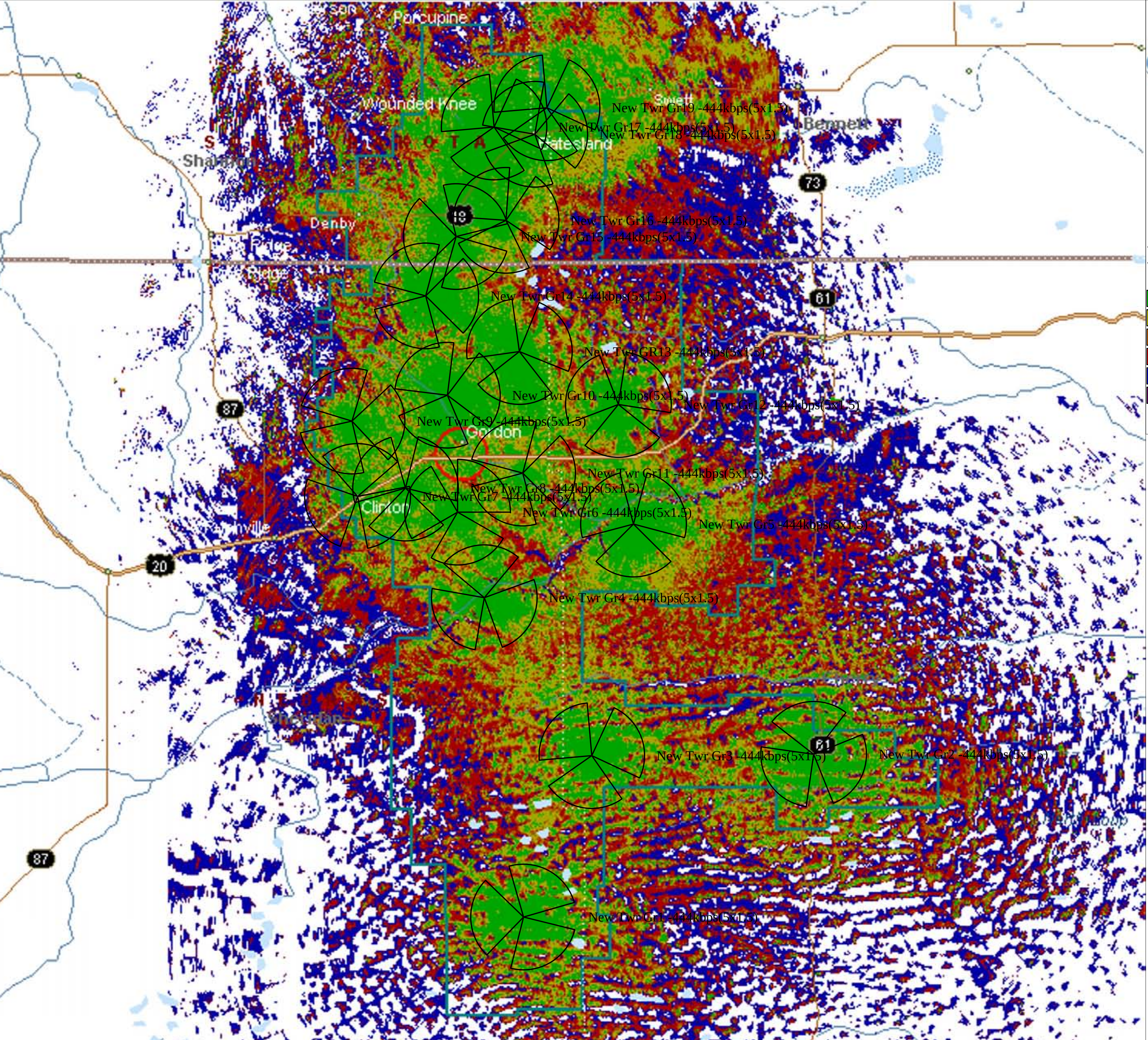
700MHz LTE System

4Mbps Service with a Busy Hour load assumption of 160kbps, assuming 5MHz Channels at 1.5bits/Hz

Legend -- Signal in dBm

green	0.00 >= n > -75.00
yellow	-75.00 >= n > -85.00
orange	-85.00 >= n > -90.00
red	-90.00 >= n > -100.00
blue	-100.00 >= n > -110.00
purple	-110.00 >= n > -115.00

Gordon Exchange



GREAT PLAINS COMMUNICATIONS

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700MHz LTE System

4Mbps Service with a
Busy Hour load assumption
of 444kbps, assuming 5MHz
Channels at 1.5bits/Hz

Legend -- Signal in dBm

0.00 >= n > -75.00
-75.00 >= n > -85.00
-85.00 >= n > -90.00
-90.00 >= n > -100.00
-100.00 >= n > -110.00
-110.00 >= n > -115.00

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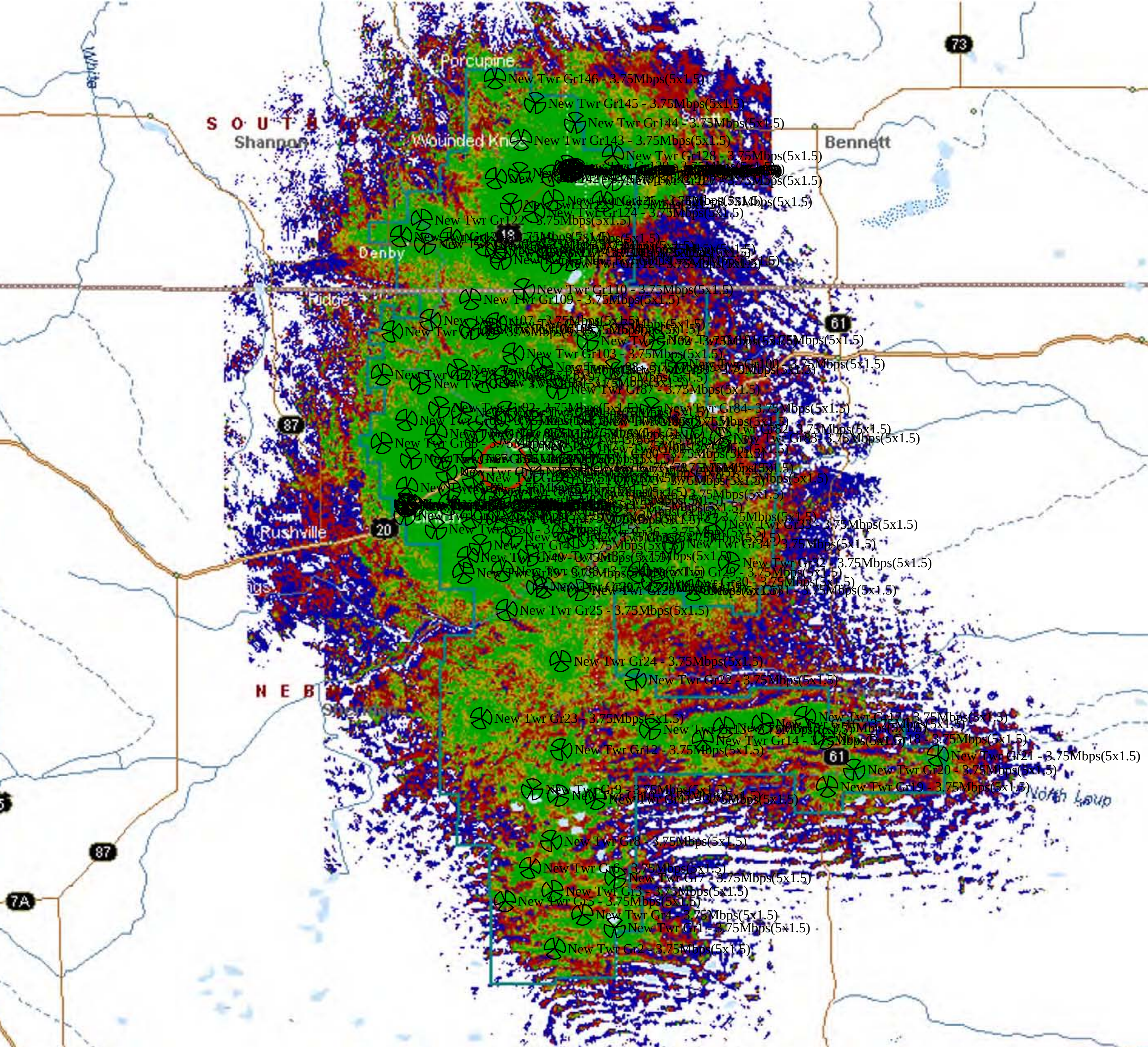

GREAT PLAINS COMMUNICATIONS

VantagePoint

Customer Focused. Technology Driven

700MHz LTE System

4Mbps Service with a Busy Hour load assumption of 3.75Mbps, assuming 5MHz Channels at 1.5bits/Hz

Legend -- Signal in dBm

Green	0.00 >= n > -75.00
Yellow	-75.00 >= n > -85.00
Orange	-85.00 >= n > -90.00
Red	-90.00 >= n > -100.00
Blue	-100.00 >= n > -110.00
Purple	-110.00 >= n > -115.00

Gordon Exchange

Appendix C – FRS Whitepaper

PROVIDING WORLD-CLASS BROADBAND:

THE FUTURE OF WIRELESS AND WIRELINE BROADBAND TECHNOLOGIES

Rural Telecom Educational Series

Prepared by

VantagePoint
Customer Focused. Technology Driven.

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PROVIDING WORLD-CLASS BROADBAND:

THE FUTURE OF WIRELESS AND WIRELINE BROADBAND TECHNOLOGIES

"And we should stretch beyond 100 megabits. The U.S. should lead the world in ultra-high-speed broadband testbeds as fast, or faster, than anywhere in the world. In the global race to the top, this will help ensure that America has the infrastructure to host the boldest innovations that can be imagined."

FCC Chairman Julius Genachowski
NARUC Conference, Washington, DC
February 16, 2009

PROVIDING WORLD-CLASS BROADBAND:

THE FUTURE OF WIRELESS AND WIRELINE BROADBAND TECHNOLOGIES

I. INTRODUCTION

It has been said that "the broadband of today is the narrowband of tomorrow." Less than 10 years ago, a 56 kbps modem was the most common method for accessing the Internet. Today, consumers are demanding 10 to 20 Mbps, or higher. Many experts agree that customers will want 100 Mbps broadband access within the next five years and 1 Gbps within the next 10 to 15 years.

Both wireless and wireline broadband access networks are used by consumers predominantly to access the global Internet. Companies that have historically been known as cable television companies, telephone companies, and cellular companies are in the process of remaking themselves into broadband companies. The goal of these broadband companies is to provide their customers with the best connection possible to enable faster Internet access and advanced services—many of which have not been invented yet.

It is difficult to overestimate the importance of broadband access to the United States' future. Broadband is becoming the lifeblood of our very economy. The Economist stated:

> "In eras past, economic success depended on creating networks that could shift people, merchandise and electric power as efficiently and as widely as possible. Today's equivalent is broadband: the high-speed internet service that has become as vital a tool for producers and distributors of goods as it is for people plugging into all the social and cultural opportunities offered by the web. Easy access to cheap, fast internet services has become a facilitator of economic growth and a measure of economic performance."[1]

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[1] The Economist, Broadband Access, January 17, 2008.

Technology advances have allowed broadband service providers new methods for providing broadband to their customers and provided significant improvements in broadband speeds. Both wireless and wireline broadband providers have benefited from technology advances, however the best *wireline* broadband technologies have historically been capable of broadband speeds that are 10 or 20 times faster than the best wireless broadband technologies. Rysavy Research stated it this way:

> "Given that the inherent capacity of one fiber optical link exceeds the entire available radio frequency (RF) spectrum, data flow over wireless links will never represent more than a small percentage of the total global communications traffic."[2]

Both wireless and wireline broadband services play important roles in the lives of most consumers and one will never displace the other. Most consumers will require the greater broadband speeds provided by a wireline provider when at home or work and need the mobility provided by the wireless provider, albeit at a slower speed. Rysavy Research also recognized that while wireless and wireline technologies sometimes compete, they are complementary in most cases.[3]

Deployment costs also vary greatly from one broadband technology to another. Some of the broadband access methods leverage existing infrastructures, while next generation broadband technologies often rely on the deployment of new infrastructures and significant investments by the broadband service provider.

This paper explores the most common methods for deploying broadband to customers along with each of their advantages and disadvantages. The broadband access methods discussed in the following pages include:

Wireless Broadband Options

- 4th Generation Wireless Broadband
  - WiMAX
  - LTE (Long Term Evolution)
- Satellite Broadband

Wireline Broadband Options

- DSL (Digital Subscriber Line)
- Cable Modems
- FTTP (Fiber-to-the-Premises)

It should be noted that there are other broadband technologies available, such as Broadband over Powerline (BPL), another wireline broadband option, and municipal Wi-Fi, another wireless broadband option. We have chosen not to address these technologies, since they are not widely deployed and many implementations have proved to have significant financial or technical challenges.

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2 Rysavy Research, EDGE, HSPA, and LTE Broadband Innovation, 3G Americas, pg. 5, September 2008.

3 Ibid., pg. 5.

II. BROADBAND CAPABILITY OVERVIEW

(TABLE 1) As consumer appetite for more bandwidth increases, broadband networks will be required to deliver more bandwidth per user. More bandwidth allows for the delivery of new and exciting applications to consumers.

Most consumers will require a wireless and wireline broadband network connection to meet their broadband needs. The wireline broadband connection is required to provide adequate bandwidth for the rich multimedia experience consumers expect in their home or business and a wireless broadband connection is required to meet their bandwidth intensive mobile requirements.

There are many ways a wireless or wireline broadband provider can deliver their broadband connection to their customers. The various methods for deploying broadband differ in cost and quality. The quality of a broadband connection is determined by four basic metrics. These are:

- the connection's speed (size of the "pipe")
- the connection's latency (delay)
- the connection's jitter (variation in packet delay)
- the service reliability

In order for consumers to realize all the benefits of broadband, they must have high quality broadband connections that meet their needs today and in the future. From the service provider's perspective, it is important that the networks they deploy today can be easily scalable to meet the broadband needs of tomorrow without a significant additional investment. Deploying broadband in rural areas and areas of low customer density present its own unique challenges. It is not uncommon for the broadband infrastructure of a rural customer to cost up to 10 times more than for an urban customer. Since the replacement costs are so high in rural areas, it becomes more crucial that the infrastructure deployed be easily upgraded to meet the customer's rapidly increasing broadband needs of the future.

> "Bandwidth-intensive applications could very quickly become the norm in the U.S.—even in rural areas. Technologies that cannot be upgraded easily could make Internet applications less than five years from now look like the dial-up downloads of today."[4]

TABLE 1: BROADBAND SPEEDS AND CONNECTIONS

Upstream and Downstream Speeds	Applications
500 kbps – 1 Mbps	Voice over IP, texting, basic e-mail, Web browsing (simple sites) streaming music (caching), low quality video (highly compressed and on a small screen)
1 Mbps – 5 Mbps	Web browsing (complex sites), e-mail (larger size attachments), remote surveillance, Standard Definition (SD) IPTV, file sharing (small/medium), telecommuting (ordinary), streaming music
5 Mbps – 10 Mbps	Telecommuting (converged services), file sharing (large), SD IPTV (multiple channels), High Definition (HD) video downloading, low definition telepresence, gaming (graphical), medical file sharing (basic), remote diagnosis (basic), remote education, building control & management
10 Mbps – 100 Mbps	Telemedicine, educational services, SD and HD IPTV, gaming (complex), telecommuting (high quality video), high quality telepresence, HD surveillance, smart/ intelligent building control
100 Mbps – 1 Gbps	HD telemedicine, multiple educational services, gaming (immersion), remote server services for telecommuting
1 Gbps – 10 Gbps	Research applications, telepresence using uncompressed HD video streams, live event digital cinema streaming, telemedicine remote control of scientific/medical instruments, interactive remote visualization and virtual reality, movement of terabyte datasets, remote supercomputing

Adapted from California Broadband Task Force, January 2008

[4] Federal Communications Commission, *Bringing Broadband to Rural America: Report on a Rural Broadband Strategy*, Michael J. Copps, Acting Chairman, May 22, 2009.

Using history as our guide, one thing is clear—the broadband of today is not adequate as the broadband of tomorrow. Over the last 10 years, consumer demand for broadband has grown even more rapidly than most experts believed it would and there is no end in sight. Even though downstream bandwidth demand is growing at a breakneck speed, upstream bandwidth is growing even faster as user-generated content becomes more widespread.

III. WIRELESS BROADBAND CAPABILITY

Wireless broadband has become a mainstream requirement for consumers. What began with simple text messaging has grown to include Web browsing, file transfer, and streaming video. There are many ways that a wireless broadband provider can deliver a broadband connection to the customer. Each method varies in cost and quality. We begin by exploring the cellular and fixed wireless methods for deploying broadband.

A. CELLULAR AND FIXED WIRELESS BROADBAND

(TABLE 2) There have historically been two distinct groups of wireless carriers. Those that are primarily focused on serving the mobile user, which we will refer to as “cellular” carriers and those that are primarily focused on serving the stationary user, which we will refer to as “fixed” wireless carriers. Normally, fixed wireless carriers can provide greater bandwidth (or throughput) to their customers at the sacrifice of mobility. As depicted in **Figure 1**, both cellular and fixed wireless technologies are converging on what is referred to as a 4th Generation (4G) network—an all-IP network having essentially the throughputs of the fixed wireless carriers along with the mobility of a cellular carrier. There are two dominant wireless technologies that fall under the 4G umbrella today—Mobile-WiMAX and Long Term Evolution (LTE).

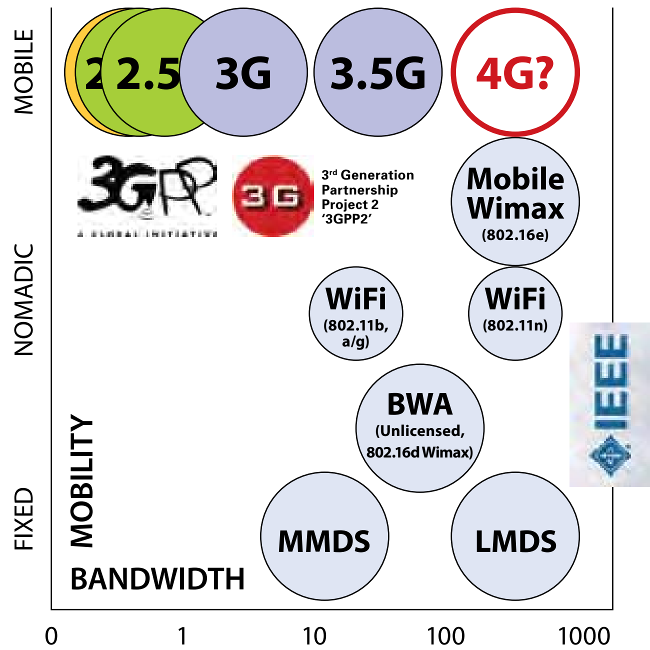

FIGURE 1: CELLULAR AND WLAN CONVERGE ON 4G

The International Telecommunication Union (ITU) has tentatively defined 4G, which it calls “IMT-Advanced,” as 1Gbps capability for stationary users and 100 Mbps for mobile users—although a typical end user customer would

TABLE 2: CELLULAR AND FIXED WIRELESS BROADBAND PERFORMANCE SUMMARY

Broadband Capability	• For each wireless access point, such as a tower, the theoretical maximum is 1 Gbps for stationary users and 100 Mbps for mobile users. The bandwidth available is shared among many subscribers, and speeds are dependent upon the number of subscribers sharing the access point. Practical implementations could allow customers to burst up to 10 or 20 Mbps for short periods of time.
Latency/Delay	• Typically low latency
Other Considerations	• Since bandwidth shared among subscribers, available bandwidth per subscriber decreases as density of subscribers increases • Available bandwidth decreases as distance of subscriber from access point increases
Overall Assessment	• Bandwidth typically adequate for limited broadband access, some data, and small screen video

only realize a small fraction of this throughput. The throughput achieved by wireless technologies is dependent upon many factors, including:

- Customer distance from tower—As the distance from the tower increases, the speed of the connection decreases.
- The number of customers sharing the same connection point.
- Available spectrum bandwidth, which is normally licensed by the Federal Communications Commission (FCC)—More spectrum bandwidth means higher connection speeds.
- Frequency of spectrum—Generally, the higher the frequency the shorter the distance.
- Obstacles (trees, hills, buildings, etc.)—Obstacles attenuate wireless signals and can reduce or prohibit broadband.
- Environmental effects—Some operating frequencies are highly susceptible to attenuation due to rain, fog, or snow, which reduces the broadband speed.

Today's two "4G" technologies (Mobile-WiMAX and LTE) can achieve 2.5 bps of actual throughput per Hz of spectrum bandwidth. This means, if a carrier has 10 MHz of spectrum, they could potentially deliver 25 Mbps to their customers. However, wireless technologies share their bandwidth among many customers. For example, if 100 customers were to share 25 Mbps, each would effectively receive 250 kbps if all were using the system at the same time. New technologies are becoming available that could increase the spectral efficiency by a factor of two to four, which experts believe is the limit of spectral efficiency. 4G wireless technologies also provide DSL-like latency (on the order of one-fourth that of 3G technologies), which is also very important for making real-time IP multimedia such as gaming and interactive video possible. As these wireless throughput speeds increase, the wireless carriers increasingly rely on the high capacity fiber optic backhaul available from the wireline providers.

Wireless carriers in the United States rely on spectrum allocated by the FCC in the 700 MHz, 850 MHz (cellular), 2 GHz (PCS and AWS)[5] and 2.5 GHz (BRS/EBS) licensed bands. Many carriers have spectrum in several of these frequency bands. In order to deliver more broadband to their customers, 4G technologies will allow wireless carriers to combine the spectrum in multiple bands to effectively make them appear as a single broadband channel.

B. SATELLITE-BASED INTERNET

(TABLE 3) Satellite broadband is normally delivered to customers using geostationary satellites. Geostationary satellites orbit the earth at the same speed as the earth's rotation, so the satellites appear to be stationary above the earth. In order to do this, they are placed into orbit more than 22,000 miles above the equator. Since the wireless signal must travel so far, satellite broadband services have very high latency and typically are not suitable for the delivery of interactive multimedia services.

To decrease the latency, there have been some efforts to deploy medium and low earth orbiting satellites, where the satellites are only a few hundred miles to a few thousand miles above the earth. At these altitudes, the satellites are orbiting the earth rapidly; many satellites are required to ensure that a subscriber has a satellite in view at all times. When used for broadband delivery purposes, these

TABLE 3: GEOSTATIONARY SATELLITE BROADBAND PERFORMANCE SUMMARY

Broadband Capability	• Shared bandwidth between subscribers • Typical packages of 512kbps to 1.5Mbps for home subscribers
Latency/Delay	• High latency
Other Considerations	• Latency not suitable for interactive applications (such as voice and videoconferencing) • Can be susceptible to rain fade (outages) • Can provide data services to very remote areas that may not be feasible for wireline or other wireless technologies
Overall Assessment	• Bandwidth capacity insufficient to meet long term needs of customers • High latency limits broadband applications

[5] (PCS) Personal Communications Service and (AWS) Advanced Wireless Service – specific spectrum bands defined by the FCC

satellite systems have historically proven to be very complex and expensive to deploy and not an effective method of broadband delivery.

While advancements in satellite technology have increased the amount of bandwidth that can be delivered to customers, the bandwidth is shared among many subscribers. Like other broadband delivery systems that have a shared access network, as the number of customers increase, the available bandwidth per customer decreases.

IV. WIRELINE BROADBAND CAPABILITIES

There are several ways a wireline broadband provider can deploy a broadband connection to their customers.

A. DSL OVER TWISTED PAIR CABLE

(TABLE 4) A telephone company's core service has historically been voice service. Twisted pair copper cable was the cable of choice and telephone companies have deployed millions of miles of twisted pair copper cable in the United States since the days of Alexander Graham Bell. Digital Subscriber Line (DSL) technologies have allowed operators to deliver broadband access to their customers over the existing copper cables. Unfortunately, broadband speeds drop quickly as the length of the twisted pair copper cable is increased due to the physical characteristics of the cable. Delivering broadband over copper cable is like water in a leaky hose—as the hose gets longer, more water leaks out along the way and less water makes it to the end of the hose.

To reduce the copper cable length and increase broadband speeds, service providers have been moving their electronics closer to the customer and connecting these electronics back to the central office using fiber optic cable. **Figure 2** shows the basic network elements for a DSL deployment. As shown, DSL networks are normally divided into serving areas where the subscribers near the central office (normally within one to three miles) are served directly from the central office and the remaining subscribers are served from remote field terminals. The size of the serving area is dependent on the type of DSL technology being used and the customer bandwidth required.

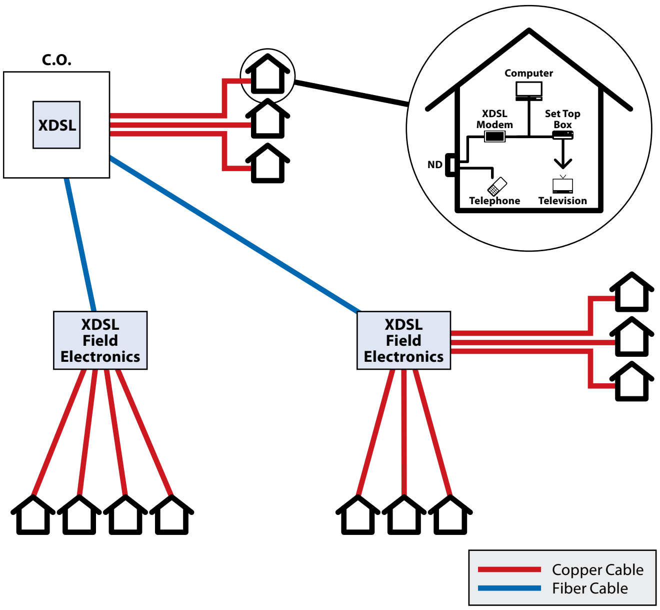

FIGURE 2: DSL NETWORK TOPOLOGY

The most common DSL technologies are Asymmetrical Digital Subscriber Line (ADSL) and Very-high-bit-rate Digital Subscriber Line (VDSL). The latest variants of these

TABLE 4: DSL OVER TWISTED PAIR BROADBAND PERFORMANCE SUMMARY

Broadband Capability	• Typically 10 to 20 Mbps for customers close to the connection point, usually more urban; could be 1 Mbps or lower for customers far from the connection point, usually more rural. • Realistic maximum: 50 Mbps over very short loops (up to 3,000 feet).
Latency/Delay	• Low latency
Other Considerations	• Attainable data rates dependent on age and quality of plant • Mature technology; few further advancements expected • Can leverage existing telco twisted pair plant • Susceptible to electrical interference
Overall Assessment	• Bandwidth capacity insufficient to meet long term customer needs

technologies are ADSL2+ and VDSL2. These technologies have been defined and standardized by the ITU-T.[6]

The latest advances in DSL have improved broadband speeds at very short copper cable lengths (less than one mile). Many rural networks are designed to have copper lengths of up to 18,000 feet. On average at these lengths, only 1 to 2 Mbps per customer is usually possible over good quality copper cable. A comparison of the data rates of the various DSL technologies is shown in **Figure 3**.

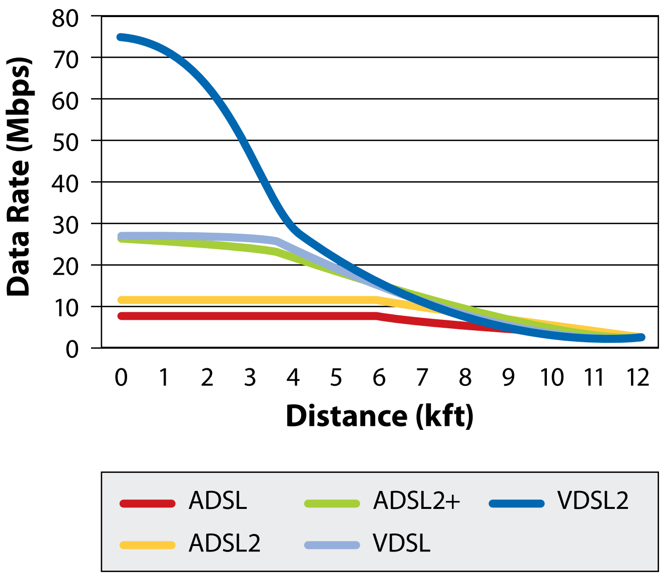

FIGURE 3: DATA RATES VS. DISTANCE

Over the past 15 years, DSL has been an effective technology for deploying broadband over existing twisted pair cable, but has been hampered by several significant limitations, such as distance, compatibility issues, the need for many field electronics, electrical interference problems, and a relatively modest broadband capability. Most service providers have realized that DSL has not been a long-term solution for broadband delivery, but it has allowed providers to deploy fiber optic cable closer to the customer and prepare for a more broadband capable network.

B. DOCSIS VIA COAX CABLE

(TABLE 5) A cable television (CATV) company's core service has historically been broadcast video. Coaxial (coax) cable was used to deliver video to their customers. The CATV industry has implemented standards called Data Over Cable Service Interface Specification (DOCSIS), which define how the coax network can be used to deliver broadband services

TABLE 5: DOCSIS OVER COAX BROADBAND PERFORMANCE SUMMARY

Broadband Capability	• Up to 160 Mbps downstream (shared among group of subscribers) with DOCSIS 3.0 • Up to 120 Mbps upstream (shared among group of subscribers) with DOCSIS 3.0
Latency/Delay	• Low latency
Other Considerations	• Increasing bandwidth requires the deployment of many fiber-fed electronics • Many systems require substantial upgrades to meet delivery requirements
Overall Assessment	• Upstream bandwidth limitations will be significant as bandwidth demands become more symmetric • Broadband capacity shared, so speeds reduce as more customers are added to the network

[6] International Telecommunication Union (ITU) – Telecommunication Standardization Sector

to customers. The capacity available on the coax cable must be allocated between video and broadband and shared by hundreds of customers that share this cable. This architecture worked well for broadcast video services, since it was a "one-to-many" service, but has limitations when delivering other services such as broadband where each customer requires a own unique connection.

DOCSIS provides the capability to give customers their own "virtual" connection across the shared coax cable by putting data on the cable at frequencies that are normally used by video channels. There are three basic methods a CATV provider can use to increase bandwidth to their customers on a coax network: 1) reduce the coax cable length to increase the available bandwidth, 2) reduce the number of customers sharing the bandwidth on each cable, and 3) implement the bonding of multiple channels together.

Figure 4 shows a modern coaxial cable system that can deliver video, high-speed data and voice services. These systems are two-way capable (downstream and upstream), and utilize fiber nodes with coax distribution to the subscriber. When used for broadcast video deployment, a fiber node can serve hundreds, or even thousands, of customers. As broadband demands increase, additional fiber nodes must be deployed closer to the customer and often serve less than 200 customers each.

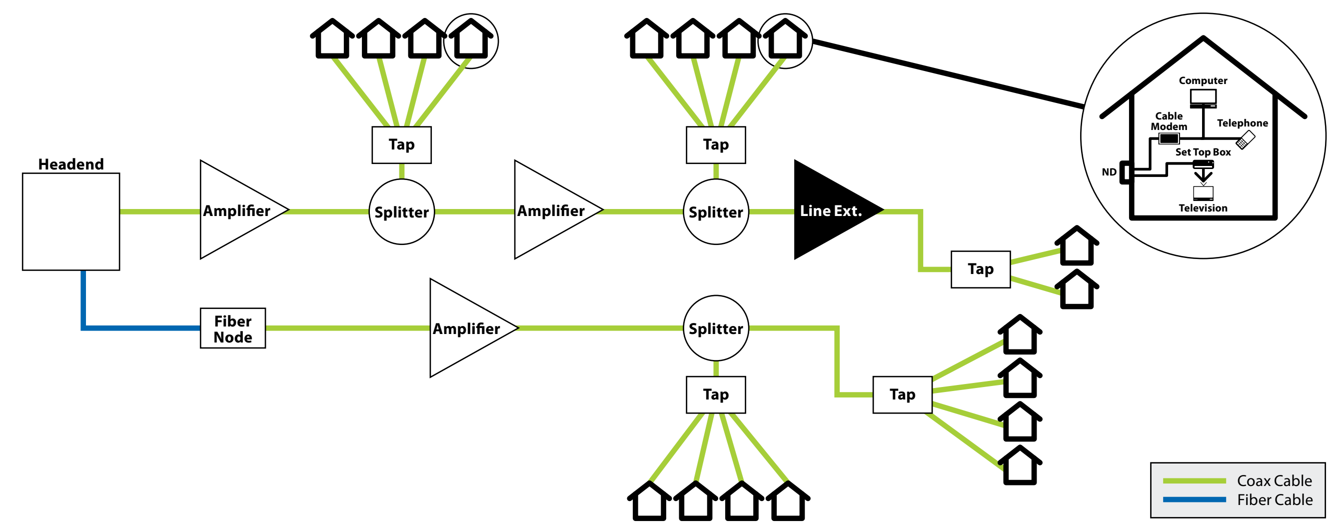

FIGURE 4: COAXIAL CABLE ACCESS NETWORK

"Building world-class broadband that connects all Americans is our generation's great infrastructure challenge."

FCC Chairman Julius Genachowski
NARUC Conference, Washington, DC
February 16, 2009

Figure 5 is a depiction of a typical coaxial cable system's channel usage. As shown, this signal on the coax cable is divided into 6 MHz segments. Analog video channels each take 6 MHz of bandwidth. As illustrated in Figure 5, a number of digital video channels can also be placed within the same bandwidth as one analog channel. The bandwidth from 0 to 54 MHz is normally reserved for upstream data (from the subscriber to the provider) and above 54 MHz is shared by video and downstream data (from the provider to the customer). It is important to note that CATV networks share bandwidth among many customers in the access network and have significant limitations in their upstream bandwidth.

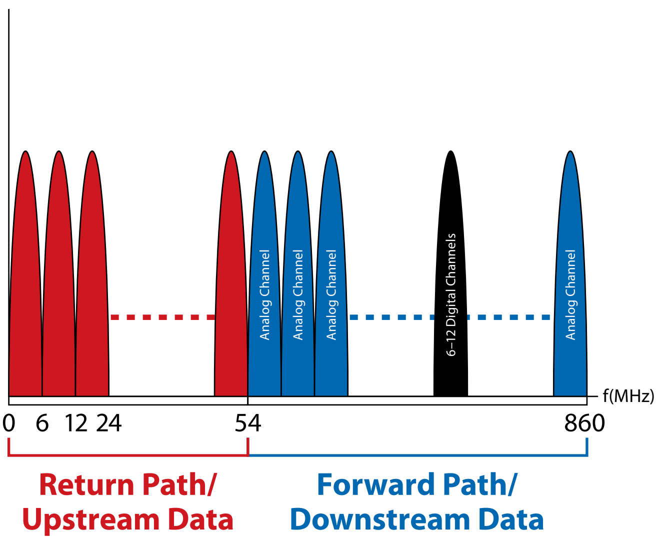

FIGURE 5: CATV SPECTRUM

In a DOCSIS configuration, several hundred users share the downstream and upstream data channels. The latest version of the DOCSIS specification is version 3.0. With DOCSIS 3.0, the 6 MHz channels can be bonded together (called a bonding group) to provide up to 160Mbps downstream and 120 Mbps upstream per bonding group. All the subscribers that are assigned to that particular bonding group share this bandwidth.

C. FIBER OPTIC CABLE TO THE PREMISES

(TABLE 6) Fiber optic cable has been used by service providers for more than 30 years to build high bandwidth (high throughput) networks, primarily for long-haul transport routes. In the last decade, fiber optic cables have been used to increase bandwidth in the customer access network as well. No other technology can deliver as much bandwidth to the customer as fiber-to-the-premises (FTTP) technologies. FTTP is sometimes referred to as fiber-to-the-home (FTTH). Fiber optics has the ability to deliver greater bandwidth over a much larger distance than other technologies. In addition, the bandwidth does not decrease as the cable length increases. Each new generation of FTTP electronics allows the service provider to offer significantly more bandwidth over greater distances. There is no end in sight as to the amount of bandwidth that is possible over fiber cables. Today, there are two main competing FTTP technologies: Gigabit-capable Passive Optical Network (GPON) and Active Ethernet. Vendors are now making Wavelength Division Multiplexing Passive Optical Network (WDM-PON), which promises even greater bandwidth to the customer. Each FTTP technology will be discussed briefly below.

Most GPON implementations use optical splitters to serve up to 32 subscribers using a single fiber from the central office. GPON technology is defined by ITU standards and currently allows for 2.4 Gbps downstream and 1.2 Gbps upstream, which is shared by the 16 or 32 customers on the same PON. Under a "worst-case" scenario where all customers are

TABLE 6: FIBER BROADBAND PERFORMANCE SUMMARY

Broadband Capability	• GPON: 75 Mbps or more; 300 Mbps planned • Active Ethernet: 1 Gbps symmetrical; 10 Gbps symmetrical planned
Latency/Delay	• Low latency
Other Considerations	• Bandwidth is not limited by distance from central office • Not susceptible to electrical interference • Dramatic increases in bandwidth are possible by changing the relatively inexpensive electronics without any outside plant cable changes.
Overall Assessment	• Provides more bandwidth than other technologies; significant bandwidth increases planned

demanding maximum bandwidth, each customer could be limited to 75 Mbps downstream and 37.5 Mbps upstream—still a respectable amount of bandwidth by today's standards. Future advancements of GPON are expected to provide a four-fold increase in bandwidth (10 Gbps downstream) and be called 10GPON. A typical PON system is shown in **Figure 6**.

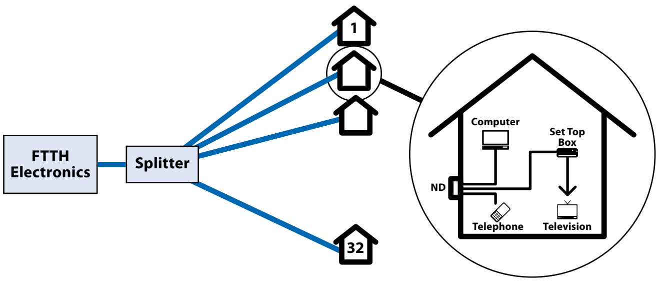

FIGURE 6: PON SYSTEM

Active Ethernet systems use a dedicated fiber between the central office and the customer, so the bandwidth consumption of one customer does not affect the amount of bandwidth available for other customers. In addition, Active Ethernet systems are symmetrical in that the downstream and upstream rates are the same. Today, most Active Ethernet systems can provide up to 1 Gbps to each subscriber—more than 10 times the bandwidth available on a GPON system. Active Ethernet has not been as widely deployed as GPON systems in the United States, since it is typically more expensive to deploy. As subscriber bandwidth demands continue to increase, Active Ethernet systems are becoming more common. A diagram showing an Active Ethernet system is shown in **Figure 7**.

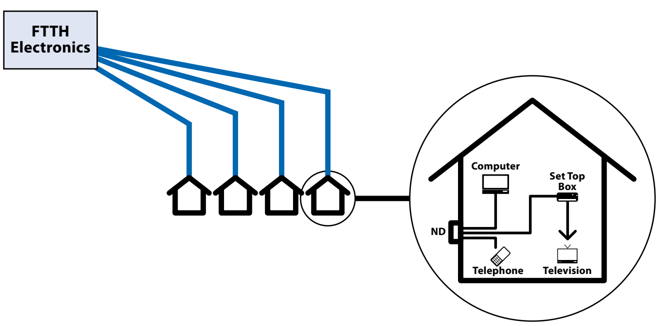

FIGURE 7: ACTIVE ETHERNET

Wavelength Division Multiplexing Passive Optical Network (WDM-PON) technologies have similarities with both GPON and Active Ethernet. Like GPON, a single fiber cable can serve multiple customers, and like Active Ethernet, each customer can have their own dedicated wavelength on the fiber. In some implementations, a small number of customers on a PON share a wavelength. Adding wavelengths on a PON network has the effect of multiplying the effective bandwidth to the customer. A WDM-PON system is depicted in **Figure 8**.

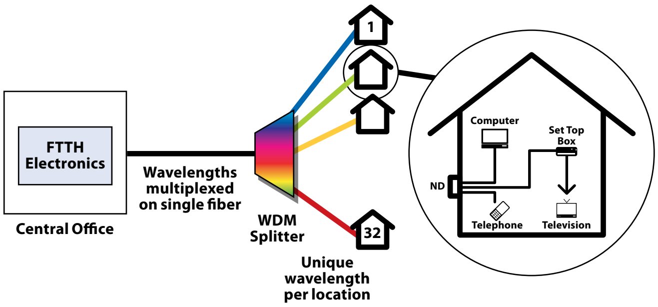

FIGURE 8: WDM-PON SYSTEM

There are currently no standards for WDM-PON. Because of the lack of standards, most vendors have not spent much time and effort in product development. Once WDM-PON is standardized and user demands increase, it may become a more popular technology for broadband deployment. WDM-PON is an example of how advancements in electronics technology can leverage an existing fiber network to provide almost limitless bandwidth potential.

V. BROADBAND DEPLOYMENT COSTS

The investment required to deploy broadband is driven by many factors. Although some of these factors are similar when comparing wireless and wireline technologies, some are very different. There are two basic measures of broadband economics:

- Broadband deployment cost per customer for a given broadband speed—This measure is useful when comparing the costs associated with different types of broadband technologies. The broadband speed assumed for the comparison is normally selected based on an established minimum broadband speed.

- Broadband deployment cost per megabit per second (Mbps) delivered to the customer—This measure is useful when determining which broadband technology is the most cost-effective to deploy. If the broadband network can easily be upgraded for more bandwidth as customer demands continue to increase, less future investment will be required.

The cost to deploy broadband can vary dramatically from one location to another. It is difficult to detail the cost of deploying broadband technology, since there are many complex factors to consider when determining the cost. We attempt to generalize the costs in the following paragraphs.

A. WIRELESS COST DRIVERS

A large portion of a wireless broadband network is the tower, tower electronics, and backhaul. Wireless broadband can be more cost effectively deployed in areas where each tower can serve a large number of customers, such as the more populated urban areas. Some of the more significant cost drivers for wireless deployments which result in increased cost include:

- Customer density
  - Low customer density—In rural areas, there are very few customers over which to spread the infrastructure costs. This results in a higher cost per customer.
  - High density—A high number of customers can overload wireless capacity and degrade service. This can be corrected through sectorization or the addition of more towers to reduce the size of the cell sites.
- Uneven terrain or obstacles—Wireless radio frequency (RF) signals used for broadband access are "line of sight." Mountains, hills, valleys, buildings, and trees interfere with the propagation of the wireless signal. These terrain issues and obstacles can mean that some customers cannot receive the broadband signal or that additional towers (and investment) are required.
- Atmospheric conditions—Temperature, time of day, humidity, and precipitation can all affect radio propagation characteristics.
- Land and right of way issues—New tower construction becomes more difficult and costly where land prices are high and where rights of way (ROW) is expensive. ROW costs increase with strict local environmental regulations, local zoning issues, protected plants or animals, or areas of historical significance.
- Frequency spectrum—Generally, more towers are required to cover an area when higher frequency bands are used. 700 MHz has a greater reach than PCS and AWS, which are located around 1,700 to 2,100 MHz. Also, the cost for spectrum acquisition can be a significant factor in the costs.

Typical material and labor costs for rural construction of a wireless infrastructure, excluding the core switching and data network, include:

- Tower (300 foot): $180K–$200K
- Land costs: $10K–$35K
- Tower electronics and antenna: $25K–$40K
- Customer premises equipment (fixed): $200–$600 per customer location

In a wireless broadband network, it is not uncommon for a tower with electronics to cost $230K to $240K. At first glance, it appears the electronics costs are small in comparison to the tower costs. However, the electronics will likely need to be replaced four or five times over a 30-year period, so with time, the electronics costs can equal or exceed the cost of the tower. In addition there are spectrum acquisition costs, backhaul costs,[7] core network costs, and interconnection costs with other carriers. Under very good conditions, a wireless broadband system may provide service up to 12 miles from the tower when using 700 MHz

[7] It should be noted that a landline fiber network will be required to provide the broadband backhaul capacity needed by the wireless network.

and normally six to eight miles when using AWS or PCS spectrum. A tower could provide service to several thousand customers in a more densely populated area, but less than 100 customers in some of the more remote rural areas.

B. WIRELINE COST DRIVERS

The largest portion of a wireline broadband network is the cable infrastructure. Wireline broadband can be more cost effectively deployed in areas where a short section of installed cable can serve a large number of customers, such as more populated urban areas. Some of the more significant cost drivers for wireline deployments, resulting in increased cost, include:

- Lower customer density—In rural areas, there are very few customers over which to spread the infrastructure costs, translating to a higher cost per customer.
- Difficult construction corridors—For buried plant, unfavorable soil conditions, such as rocks, lava flows, as well as lakes, rivers, forested areas, railroad crossings, and other challenging corridors, make construction difficult.
- Land and right of way issues—Cable construction becomes more difficult and costly where land prices are high and where ROW is expensive. ROW costs increase with strict local environmental regulations, protected plants or animals, or areas of historical significance.

- Labor and fuel costs—Cable construction is labor intensive and relies on the use and transportation of large equipment. Typically, 60%-80% of the construction costs are labor-related rather than the cable material costs.

Typical material and labor costs for rural construction of a FTTP infrastructure, excluding core network costs, include:

- Typical fiber cable construction (rural): $7k–$50k per mile or $5k–$25k per customer location
- Typical fiber cable construction (town): $10–$30 per foot or $2.5k per customer location[8]
- Central office and customer premises electronics: $500–$750 per customer location

In addition there are transport costs, switching costs, and interconnection costs with other carriers. A FTTP network is typically designed to reach customers that are up to 12 miles from the electronics, but technology exists to allow reaching customers 20 or more miles from the electronics location.

C. WIRELESS VS. WIRELINE COST OBSERVATIONS

Often, the initial capital expenditure for a wireless network is less than the capital expenditure for a FTTP network. However, it is important to note the following:

- A lion's share of the FTTP investment is the cable, which with a 30-year life, compared to the wireless infrastructure, has a greater portion of the investment associated with faster depreciating infrastructure. When replacement costs are included over a 30-year life, the cost savings for a wireless network is significantly reduced or eliminated.
- The amount of bandwidth per customer is significantly greater for a FTTP network when compared to a wireless network. Using the technologies available today, the bandwidth delivered to a customer can be more than 100 times greater than what is possible over a wireless network under similar conditions. The bandwidth advantage for FTTP will increase significantly in the coming years due to technology advances with the electronics.

---

8 Town construction is normally much more expensive per foot than rural construction due to the additional expenses associated with easement and rights of way, increased labor due to placing the cable under streets and driveways, constructing around existing utilities, and the additional splicing required. Also, access to the cable is more frequent, resulting in more handholes, manholes, and pedestals.

When the costs are calculated for a 30-year period, the investment required for FTTP and a 4G wireless network are not significantly different. It should be remembered, however, that wireless and wireline broadband technologies should not be considered competing technologies as most customers will require both.

VI. CONCLUSION

(TABLE 7) World-class broadband is essential for the United States to effectively compete in the global economy. Consumers will require a landline broadband service to satisfy their high bandwidth needs, such as entertainment video, graphic intensive gaming, and cloud computing. They will also require a mobile broadband service for limited video and mobile communications including e-mail, messaging, and social networking. Because of fundamental limitations in the radio spectrum, wireless broadband has practical capacity limits and will not be able to provide enough throughput to serve the broadband needs of all consumers.

Over the next few years, the major wireless carriers will migrate their networks to 4G, at least in the more densely populated areas. One factor in determining the bandwidth available over these 4G networks is the broadband capacity of the landline carrier providing the backhaul. The 4G wireless towers require high capacity connections, typically using Ethernet delivered over a landline carrier's fiber network.

Most consumers will require both a fixed and mobile broadband connection for the unique benefits each can provide. To meet the ultra-high-speed broadband needs of their customers, landline carriers must continue to deploy fiber closer to their customers—with the ultimate goal of eliminating the copper cables from their network entirely in favor of fiber. To meet the mobile broadband needs of their customers, the wireless carriers must continue to upgrade their networks to 4G technologies. The investment on the part of the wireless and wireline carriers to achieve this will be large, but the cost of failing will be even larger.

TABLE 7: BROADBAND PERFORMANCE SUMMARY

Average Broadband Speeds (Per User)	Applications	Wireline			Wireless		
		Twisted-Pair Copper	Coax	Fiber	4G Fixed	4G Mobile (Cellular)	Satellite
Low Speed Broadband (<1Mbps)	VoIP, basic email and simple web browsing	Excellent	Excellent	Excellent	Excellent	Excellent	Poor (latency)
Medium Speed Broadband (1Mbps to 10Mbps)	Basic telecommuting, file sharing, SD IPTV, basic interactive video, basic remote education	Very Good	Excellent	Excellent	Very Good	Good	Poor (latency and bandwidth)
High Speed Broadband (10Mbps to 100Mbps)	Telemedicine, complex remote education, high quality telecommuting, HD IPTV, advanced interactive video	Good	Good	Excellent	Poor	Poor	N/A
Ultra High Speed Broadband (> 100Mbps)	Research application, HD telepresence, virtual realities, remote supercomputing	Poor	Poor	Excellent	N/A	N/A	N/A

Foundation for Rural Service

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Attachment B: Summary of the Nebraska Universal Service Fund High-Cost Program

Summary of the Nebraska Universal Service Fund High-Cost Program

The Nebraska Universal Service Fund (NUSF), established in 1999, is program that as modified in 2005 targets and distributes high-cost support for capital expenditures and expenses that carriers incur to deploy and operate broadband-capable networks in the most-rural areas of the state.

Following authorization by the Nebraska Legislature in 1997, the Nebraska Public Service Commission (NPSC) adopted in 1999 a policy to rebalance intrastate access and local service rates to eliminate implicit subsidies and thereby facilitate competition among local service providers, and simultaneously established the NUSF to compensate carriers for revenue reductions due to the substantial reductions in cost-based access rates the Commission's policy would require. From 1999 through 2004, the basis of NUSF support provided to each eligible carrier was the projected net revenue loss as a result of reducing its state access rates while also raising its local service rates to uniform benchmark rates – $17.50 per month for residential service; $27.50[1] per month for business service. This rate-rebalancing, revenue-neutral high cost support mechanism was intended to be an interim program, and in 2001 the NPSC opened a formal proceeding to develop a permanent distribution methodology.

The design of the permanent new NUSF distribution mechanism, called the "Support Allocation Methodology" (SAM) was completed in 2004 and implemented in January 2005. Under the SAM, each qualifying carrier's annual NUSF support is determined through a multi-step process and depends on several factors – including household density in out-of-town service areas, per-line access revenue, earnings on net investment during a prior year, and level of NUSF support at the end of the interim program.

At the core of the SAM are mathematical models of the costs and revenues attributable to the local loop. Each carrier's loop cost is modeled separately for the in-town and out-of-town portions of each of its exchanges,[2] according to an exponential function of household density that approximates the relationship between loop cost and household density indicated by the Benchmark Cost Proxy Model (BCPM).[3] At the low end, modeled loop costs for Nebraska's cities and towns range from as low as a penny per month to about $20 per month. Modeled loop costs for out-of-town areas range from

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[1] These rates do not include the federal subscriber line charge.

[2] The entire state is divided into 1,632 Support Areas, of two kinds: In-Town and Out-of-Town. In-Town Support Areas are defined as "cities, villages, or unincorporated [census block] areas with 20 or more households and densities greater than 42 households per square mile." Out-of-Town Support Areas are defined as those areas within an exchange that are not included in any In-Town Support Area.

[3] The following formula is used to calculate monthly Loop Cost within each Support Area "i", as an exponential function of the household density within that Support Area:

$$(\text{Loop Cost})_i = \alpha e^{-\beta * \text{HouseholdDensity}_i}$$

where:

- $\alpha = 604.74$ and $\beta = 0.51197$ for HouseHoldDensity ≤ 4.5,
- $\alpha = 80.939$ and $\beta = 0.040666$ for $4.5 <$ HouseHoldDensity ≤ 34,
- $\alpha = 20.487$ and $\beta = 0.00026585$ for $34 <$ HouseHoldDensity;
- $\text{HouseholdDensity}_i$ = household density in Support Area "i";
- e = the base of the natural logarithms (approx. 2.71828).
-

about $40 per month in areas characterized by suburban acreages and small farms to more than $500 per month in Nebraska's ranch country, where a single household is found on average every three to five square miles. Modeled loop revenue includes contributions from the uniform local service rate benchmark (now increased to $19.95 for residential lines in rural areas), the federal subscriber line charge, per-line intrastate access revenue and digital subscriber line service.[4] Modeled revenue ranges from $25 per month for Nebraska's two non-rural carriers (Qwest and Windstream) that have lower intrastate access rates to more than $75 per month for one rural carrier with fewer than 600 access lines. Modeled monthly revenue for most rural carriers is between $30 and $45.

It is important to note that the NUSF is not sufficiently sized to fund all support that the SAM identifies is required to deploy and maintain facilities to all high-cost areas of the state. NUSF support amounts are determined annually by allocating a fixed fund size that is based on a surcharge of 6.95 percent of all intrastate telecommunications revenues earned by Nebraska telecommunications service providers. The surcharge was established at the onset of the NUSF in 1999 to replace on a revenue-neutral basis the support all carriers had received previously. The NPSC sets the NUSF surcharge each year and has maintained it at 6.95 percent for all years but one.

Allocations are made in proportion to the amount by which each carrier's modeled loop cost exceeds its modeled loop revenue.[5] Annual NUSF high-cost funding rose to $71 million in 2004 and has declined under the permanent methodology to approximately $62 million in 2007 and less than $50 million in 2010. This funding decrease is because the amount of assessable intrastate telecommunications revenues has declined, and the NPSC

---

[4] Monthly loop revenue is deducted from monthly Loop Cost to determine monthly Nominal Loop Support. Loop Revenue (per month) is calculated for company "j" according to the following formula:

$$\text{Loop Revenue}_j = \text{SAM-BM}_j = [(\text{Residential Benchmark})*(86\%)+\text{Adder-Adjustments}_j]*[1.15]$$

where:

- SAM-BM_j stands for "Support Allocation Methodology Benchmark" for company "j";
- 86% is used because BCPM shows that loop cost is 86% of the total cost of local service, averaged across all of Nebraska (the other portions being switching and transport);
- 1.15 represents the number of loops, or access lines, per household;
- "$\text{Adder-Adjustments}_j$" is the sum of the following three terms for company "j":
  - SLC $\text{Adder-Adjustment}_j$: Company-specific amount (most are $6.50);
  - DSL Adder-Adjustment: $1.60 for all companies;
  - Access $\text{Adder-Adjustment}_j$: Company-specific amount.

[5] $\text{Nominal Area Support}_{ij} = (\text{Loop Cost}_i - \text{Loop Revenue}_j) \times \text{Number of Households}_i$

- If "$\text{Loop Cost}_i - \text{Loop Revenue}_j$" is less than zero, $\text{Nominal Loop Support}_{ij}$ is set to zero.

Nominal Area Support is then normalized against the annual Model Fund Size to produce an annual Support Area Allocation amount for each Support Area,

$$\text{Support Area Allocation}_i = \text{Nominal Area Support}_i \,/\, \Sigma_i (\text{Nominal Area Support}_i) \times \text{Model Fund Size}$$

has not wanted to further burden Nebraska consumers who pay both the federal USF and the NUSF surcharges.

The baseline NUSF support amounts determined by the cost and revenue modeling are subject to an earnings cap and are reduced by a "rural benchmark" adjustment mechanism. The earnings cap ensures that no carrier receives NUSF support that would cause its return on net plant investment to exceed 12 percent. The rural benchmark adjustment reflects the Commission's policy determination that a $2 per month difference between urban and rural residential local service rates is consistent with the statutory goal of "reasonably comparable" rates in urban and rural areas. Thus, carriers' NUSF is reduced by $2 per month for each out-of-town customer.

The permanent NUSF also has recognized the need for a transition for the initial years of its implementation. In the first four years of the SAM (2005-2009), transitional mechanisms were implemented to "soften" the impact of dramatically reduced NUSF support calculated by providing NUSF support via the SAM-calculated amounts to those carriers that would otherwise experience severe reductions in support.

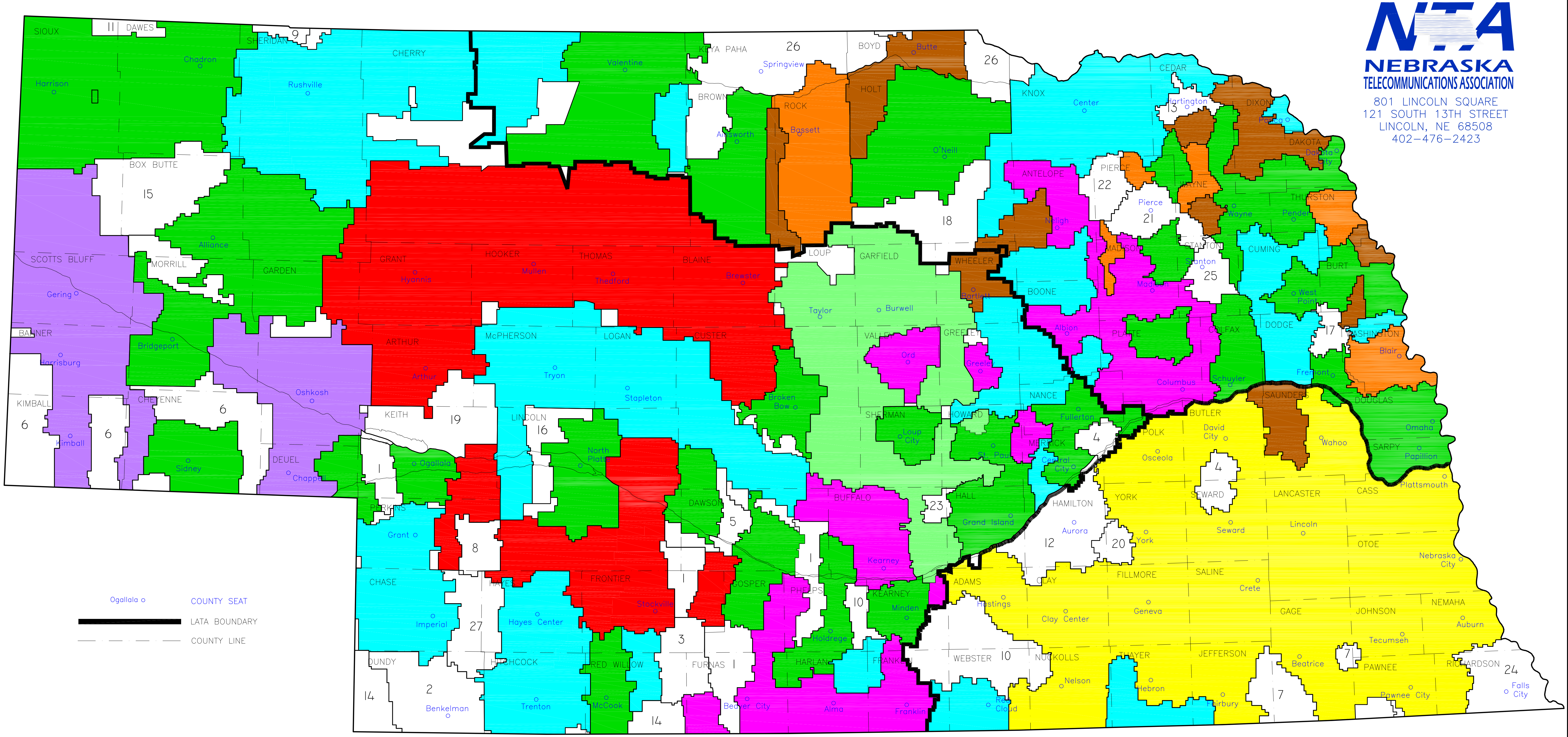
Recognizing that the purpose of high cost universal service support is not to artificially create competition in markets in which it is economically unsustainable, the NPSC has adopted a rebuttable presumption that funding should support a single network, and that NUSF support to competitive carriers should be limited to those that lease unbundled network element loops from non-rural incumbents at cost-based prices. Nevertheless, the Commission has articulated a procedure by which facilities-based competitors can challenge this presumption by demonstrating how the public interest would be served by supporting more than one network in a given area.

NUSF-eligible carriers include two non-rural carriers that together serve about two-thirds of Nebraska's access lines, nearly 35 rural companies, most of which serve a few hundred to a few thousand lines each, and a small number of competitive carriers that lease loops from the non-rural carriers.

Attachment C: Map of Nebraska illustrating County Boundaries and Service Areas of Incumbent Local Exchange Carriers

NTA
NEBRASKA TELECOMMUNICATIONS ASSOCIATION

801 LINCOLN SQUARE
121 SOUTH 13TH STREET
LINCOLN, NE 68508
402-476-2423



WINDSTREAM
CITIZENS COMMUNICATIONS, KEARNEY
GREAT PLAINS COMMUNICATIONS, BLAIR
CONSOLIDATED TELEPHONE, LINCOLN
NEBRASKA CENTRAL TEL. CO., GIBBON
NORTHEAST NEBR. TEL. CO., JACKSON
QWEST
AMERICAN BROADBAND
CENTURYLINK

1 ATC COMMUNICATIONS
2 BENKELMAN TEL. CO.
3 CAMBRIDGE TEL CO.
4 CLARKS TEL. CO.
5 COZAD TEL. CO.
6 DALTON TEL. CO.
7 DILLER TEL. CO.
8 ELSIE COMMUNICATIONS
9 EXTENSION TEL. CO.
10 GLENWOOD TEL. MEMB. COOP., BLUE HILL
11 GOLDEN WEST WALL, S.D.
12 HAMILTON TELEPHONE CO.
13 HARTINGTON TEL CO.
14 HARTMAN TEL. EXCHANGES, DANBURY
15 HEMINGFORD CO-OP TEL. CO.
16 HERSHEY CO-OP TEL. CO.
17 HOOPER TEL. CO.
18 K & M TEL. CO., CHAMBERS
19 KEYSTONE ARTHUR TEL. CO., KEYSTONE
20 MAINSTAY COMMUNICATIONS, HENDERSON
21 PIERCE TEL. CO.
22 PLAINVIEW TEL. CO.
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